

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1—Iron and Steel Manufacturing (40 CFR Part 420)*

- Reviewed available data in Canada’s National Pollutant Release Inventory (NPRI) to identify any additional pollutants that may be present in iron and steel manufacturing wastewater discharges that are not reported in the U.S. under the TRI or DMR programs.

Table 4-2 compares the 2013 and 2014 TRI and DMR TWPE and the number of facilities reporting discharges of the four pollutants. Section 4.1.4 presents EPA’s analyses and results related to lead, nitrate, copper, and manganese. Section 4.1.5 presents EPA’s analysis of the NPRI data.

**Table 4-2. 2013 and 2014 DMR and TRI TWPE and Number of Iron and Steel Manufacturing Facilities Discharging Lead, Manganese, Nitrate, and Copper**

Pollutant	2014 TRI Data		2013 TRI Data		2014 DMR Data		2013 DMR Data	
	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE
Lead	136	15,400	133	20,600	36	4,190	37	8,760
Manganese	115	13,000	114	5,680	8	2,140	8	1,760
Nitrate	57	27,700	56	25,400	3	329	3	502
Copper	84	5,020	79	4,990	30	2,650	34	3,760
<b>Total for All Pollutants Reported</b>	<b>221</b>	<b>85,900<sup>b</sup></b>	<b>215</b>	<b>82,600<sup>c</sup></b>	<b>70</b>	<b>116,000<sup>b</sup></b>	<b>80</b>	<b>182,000<sup>c</sup></b>

Sources: *TRILTOOutput2014\_v1*; *TRILTOOutput2013\_v1*; *DMRLTOOutput2014\_v1*; *DMRLTOOutput2013\_v1*.

Note: Sums of individual values may not equal the total presented, due to rounding.

<sup>a</sup> Number of iron and steel manufacturing facilities with TWPE greater than zero.

<sup>b</sup> EPA did not complete a comprehensive quality review of the remainder of the 2014 TRI and DMR data; therefore, this total may include outliers. See Section 2.1 for more information.

<sup>c</sup> Total includes corrected data as identified during the 2015 Annual Review (U.S. EPA, 2016a).

#### **4.1.4 Iron and Steel Manufacturing Category Review of Lead, Nitrate, Copper, and Manganese**

During the 2002 rulemaking, EPA collected information about the concentrations of lead, nitrate, copper, and manganese in iron and steel manufacturing discharges, and calculated, for certain subcategories, long-term averages (LTAs) reflecting various technology bases. These LTAs are the average performance level that a facility with well-designed and operated model pollution removal technologies is capable of achieving for the subcategory based on the data collected during the 2002 rulemaking.

For reasons cited in the Iron and Steel Manufacturing Development Document and 2002 final rule, and described briefly in the subsections below, EPA did not revise the ELGs for lead using the subcategorization scheme from the proposed rule and did not establish limitations for nitrate, copper, or manganese (see 67 FR 64216 and (U.S. EPA, 2002)). However, for the purpose of this preliminary category review, the LTAs developed as part of the proposed rule provide an indication of the performance of available technologies evaluated at the time of the rulemaking and serve as a useful basis for comparison and understanding of current lead, nitrate,

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

---

copper, and manganese discharges. EPA notes that for many of the proposed subcategories, wastewater flow reduction steps, in concert with better performance of blowdown treatment systems, provided the primary basis for the proposed limitations and standards (67 FR 64216).

For this review, EPA obtained current direct and indirect discharge concentrations of lead, nitrate, copper, and manganese from iron and steel manufacturing facilities following the methodology outlined in Section 2.1.4. Specifically, EPA compiled average concentration data for nitrate, copper, and manganese reported on DMRs. Additionally, EPA identified and contacted 16 facilities to understand reported releases to TRI and gather underlying concentration data that formed the basis for the TRI-reported direct and indirect releases of lead, nitrate, copper, and manganese (compiled in ERG, 2016 and summarized below). EPA compared these concentration data to the LTAs achieved by technologies evaluated during the 2002 Iron and Steel Manufacturing rulemaking to provide a frame of reference for the magnitude of the discharges and to identify potential changes to discharges since 2002. For this analysis, EPA did not attempt to subcategorize the facility concentration data for a more specific comparison to the relevant LTAs. EPA compared the concentrations to the range of LTAs identified during the 2002 rulemaking across the subcategories.

Table 4-3 lists the facilities EPA contacted, along with information they provided regarding their process operations and treatment technologies. Nine facilities reported direct releases and seven reported indirect releases of one or more of the pollutants reviewed. Of these 16 facilities, EPA did not obtain concentration data from one direct discharger (IPSCO Tubulars Inc., Wilder, Kentucky) and three indirect dischargers (ADCOM Wire Co., Jacksonville, Florida; O&K American Corporation, Chicago, Illinois; and Jewel Acquisition LLC, Louisville, Ohio). EPA presents its analysis of the DMR and TRI-based concentration data for lead, nitrate, copper, and manganese in Sections 4.1.4.1 through 4.1.4.4, respectively.

To further understand discharges and treatment of lead, nitrate, copper, and manganese, EPA contacted two states, Indiana and West Virginia, that have a high proportion of iron and steel manufacturing facilities with reported lead, nitrate, copper, and/or manganese discharges. EPA also evaluated available treatment technology pollutant removal data. Sections 4.1.4.5 and 4.1.4.6 present the results of these analyses.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-3. Facilities Contacted to Obtain Underlying Concentration Data for Pollutant Releases Reported to TRI in 2014**

Facility Name	Facility Location	Facility-Provided Process and Treatment Technology Information <sup>a</sup>	Direct or Indirect Releases	Pollutant(s)	Concentration Data Provided <sup>b</sup>	Reference
AK Steel Corp – Coshocton Works	Coshocton, OH	Nitrate discharges result from pickling of stainless steel, a process that uses a large amount of nitric acid.	Direct	Nitrate, Manganese	Yes	(Montag, 2016)
Arcelormittal Burns Harbor LLC	Burns Harbor, IN	No process or treatment technology information provided.	Direct	Lead	Yes	(Bley, 2016)
Arcelormittal Wierton LLC	Weirton, WV	Lead releases result from the tin plating process. Facility does not have treatment technologies installed to target the removal of lead. Copper and manganese are byproducts of the tin plating process and marked as an impurity.	Direct	Lead, Copper, Manganese	Yes	(Mieczkowski, 2016)
IPSCO Tubulars, Inc.	Wilder, KY	Facility contact did not respond.	Direct	Lead, Manganese	No	(Clifton, 2016)
NLMK Pennsylvania Corp	Farrell, PA	The facility is a steel mill and certain grades of steel that they roll can contain manganese. A small portion of the manganese generated is discharged in the wastewater, while the majority of it ends up in the sludge. Another source of manganese is the steel slabs that the facility purchases. The facility currently has clarifiers for settling, but no specific treatment technologies in place for manganese.	Direct	Manganese	Yes	(Herman, 2016)
USS Gary Works	Gary, IN	Releases result from sinter, iron and steel production, coke production, and rolling and finishing operations.	Direct	Lead, Nitrate, Copper, Manganese	Yes	(Lasko, 2016)
USS Mon Valley Works – Edgar Thompson Plant	Braddock, PA	Releases result from steel production, specifically from the caster.	Direct	Lead, Nitrate, Copper, Manganese	Yes	(Lasko, 2016)
USS Mon Valley Works – Irvin Plant	West Mifflin, PA	Releases result from hot rolling and finishing operations.	Direct	Lead, Nitrate, Manganese	Yes	(Lasko, 2016)
US Steel Corp – Fairfield Works	Fairfield, AL	Releases result from iron production and steel finishing.	Direct	Lead, Copper, Manganese	Yes	(Lasko, 2016)
ADCOM Wire Co.	Jacksonville, FL	The facility manufactures wire. Lead is found in the wastewater from the lead-wire base.	Indirect	Lead	No	(Killian, 2016)

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

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Facility Name	Facility Location	Facility-Provided Process and Treatment Technology Information <sup>a</sup>	Direct or Indirect Releases	Pollutant(s)	Concentration Data Provided <sup>b</sup>	Reference
Carpenter Technology Corp.	Reading, PA	Copper is introduced to the wastewater from plating and stripping operations. The facility performs chemical precipitation in order to treat the wastewater on-site before sending the discharges to the POTW.	Indirect	Copper	Yes	(McGowan, 2016)
DW–National Standard – Stillwater LLC	Stillwater, OK	Lead and copper releases result from raw materials used in carbon steel wire production.	Indirect	Lead, Copper	Yes	(Banks, 2016)
Jewel Acquisition LLC	Louisville, OH	The facility performs pickling operations with nitric acid that may result in discharges of lead, nitrate, copper, and manganese. The facility uses neutralization combined with settling for pretreatment before discharging wastewater to the POTW.	Indirect	Lead, Nitrate, Copper, Manganese	No	(Calderazzo, 2016)
O&K American Corporation	Chicago, IL	Lead and manganese releases result from steel wire production using an acid pickling operation. The facility has a conventional precipitation wastewater treatment system.	Indirect	Lead, Manganese	No	(Welsh, 2016)
SWVA, Inc.	Huntington, WV	Lead releases result from melting steel. Lead is not added but enters the wastewater from the melting of raw materials.	Indirect	Lead	Yes	(Artrip, 2016)
Valbruna Slater Stainless Steel	Fort Wayne, IN	Releases result from hot rolling and cold finishing operations.	Indirect	Copper, Manganese	Yes	(Hacker, 2016)

<sup>a</sup> This table reflects only the information provided by facility contacts.

<sup>b</sup> EPA compiled the concentration data provided by the facilities into a spreadsheet to support the analyses discussed in this section (ERG, 2016).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

#### 4.1.4.1 Evaluation of Lead Discharge Concentrations

During the 2002 Iron and Steel Manufacturing rulemaking, EPA evaluated discharges and calculated LTAs for lead reflecting technology bases for the proposed subcategories considered during the development of the rulemaking (see 65 FR 81963). Table 4-4 lists the technology bases and lead LTAs extracted from the Iron and Steel Manufacturing Development Document (U.S. EPA, 2002).

**Table 4-4. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA Lead Values by Subcategory**

Subcategory (Segment)	Option	Technology Basis	LTA for Lead (µg/L)
Non-Integrated Steelmaking and Hot Forming (Carbon and Alloy)	BAT	High-rate recycle systems and associated treatment for solids removal (scale pits, clarification, filtration), and water cooling prior to reuse. Multimedia (mixed media) filtration removes solids not removed by scale pits and clarification.	6.43
Finishing (Carbon and Alloy)	BAT	In-process technologies include flow reduction through countercurrent rinsing, recycle of fume scrubber water, and reuse of acid. End-of-pipe treatment includes oil removal, flow equalization, hexavalent chromium reduction (for certain waste streams), metals precipitation, gravity clarification, sludge dewatering.	7.54
Integrated Steel (Carbon and Alloy)	BAT	High-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels to reuse and treatment of blowdown with multimedia filtration.	14.1
Integrated Steel (Stainless)	BAT	High-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels to reuse and treatment of blowdown with multimedia filtration.	69.3

Source: (U.S. EPA, 2002)

BAT: Best Available Technology Economically Achievable

#### *Evaluation of Direct Discharge Lead Concentrations*

For this analysis, EPA obtained lead concentration data from 35 iron and steel manufacturing facilities: 28 from data reported on 2014 DMRs and seven from facilities reporting direct releases to TRI in 2014. Table 4-5 summarizes the average iron and steel manufacturing direct discharging facility 2014 DMR and TRI lead concentration data. EPA compared the range of facility concentrations shown in Table 4-5 to the lead LTAs from the 2002 rule listed in Table 4-4. The comparison shows that the median lead concentrations from DMR and TRI data are below the LTAs for all subcategories.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-5. Iron and Steel Manufacturing Facility 2014 Average Direct Discharge Lead Concentration Data**

Data Type	Number of Data Points <sup>a</sup>	Average Lead Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Iron and Steel Facility DMR Data	59	0	2.50	114
2014 Iron and Steel Facility TRI Data	28	Non-detect	2.82	355

Source: *DMRLTConcOutput2014\_v1*; (ERG, 2016)

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

### ***Evaluation of Indirect Discharge Lead Concentrations***

For this analysis, EPA obtained lead concentration data from two iron and steel manufacturing facilities reporting indirect releases to TRI in 2014. Table 4-6 summarizes the average iron and steel manufacturing facility 2014 TRI lead concentration data being sent to POTWs. EPA compared these concentrations to the lead LTAs from the 2002 rule listed in Table 4-4. The comparison shows that SWVA Inc.’s average lead concentration is above the LTAs for all subcategories and DW – National Standard’s average lead concentration is above the LTAs for all subcategories except the integrated steel subcategory, stainless segment. However, the concentrations listed in Table 4-6 represent concentrations from facilities reporting the highest indirect releases of lead to TRI.

**Table 4-6. Iron and Steel Manufacturing Facility 2014 Average Indirect Discharge Lead Concentration Data**

Facility Name and Location	Average Lead Concentration
SWVA, Inc., Huntington, WV	110 µg/L
DW – National Standard – Stillwater LLC, Stillwater, OK	59.8 µg/L

Source: (ERG, 2016)

### **4.1.4.2 Evaluation of Nitrate Discharge Concentrations**

During the 2002 rulemaking, EPA evaluated discharges and calculated LTAs for nitrate reflecting technology bases for the proposed subcategories considered during the development of the rulemaking. Table 4-7 lists the technology bases and nitrate LTAs extracted from the Iron and Steel Manufacturing Development Document (U.S. EPA, 2002).

**Table 4-7. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA Nitrate Values by Subcategory**

Subcategory (Segment)	Option	Technology Basis	LTA for Nitrate (mg/L)
Finishing (Carbon and Alloy)	BAT	In-process technologies include flow reduction through countercurrent rinsing, recycle of fume scrubber water, and reuse of acid. End-of-pipe treatment includes oil removal, flow equalization, hexavalent chromium reduction (for certain waste streams), metals precipitation, gravity clarification, sludge dewatering.	0.114

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-7. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA Nitrate Values by Subcategory**

<b>Subcategory (Segment)</b>	<b>Option</b>	<b>Technology Basis</b>	<b>LTA for Nitrate (mg/L)</b>
Cokemaking (Byproduct Recovery)	PSES	Emission control scrubber blowdown to coke quench stations, oil and tar removal, flow equalization, free and fixed ammonia stripping, and post ammonia stripping equalization.	0.831
Integrated Steel (Stainless)	BAT	High-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels to reuse and treatment of blowdown with multimedia filtration.	1.95
Cokemaking (Byproduct Recovery)	BAT	Emission control scrubber blowdown to coke quench stations, oil and tar removal, flow equalization, free and fixed ammonia distillation (stripping), indirect cooling, flow equalization, biological treatment and secondary clarification, sludge dewatering.	114

Source: (U.S. EPA, 2002)

BAT: Best Available Technology Economically Achievable

PSES: Pretreatment Standards for Existing Sources

### ***Evaluation of Direct Discharge Nitrate Concentrations***

For this analysis, EPA obtained nitrate concentration data from six iron and steel manufacturing facilities; two from data reported on 2014 DMRs and four from facilities reporting direct releases to TRI in 2014. Table 4-8 summarizes the average iron and steel manufacturing direct discharging facility 2014 DMR and TRI nitrate concentration data. EPA compared the range of facility concentrations shown in Table 4-8 to the nitrate LTAs from the 2002 rule listed in Table 4-7. EPA also contacted one facility that reported indirect releases of nitrate to TRI (Jewel Acquisition LLC, Louisville, Ohio), but was unable to obtain any data. This facility accounted for 56 percent of the 2014 TRI nitrate releases. Because EPA did not obtain any data on nitrate concentrations in indirect releases, the discussion below is limited to direct discharges.

The comparison to the LTAs (from Table 4-7) shows that the median nitrate concentrations in both data sets are above the finishing subcategory and cokemaking subcategory, PSES option LTAs, similar to the integrated steel subcategory LTA, and below the cokemaking subcategory, BAT option LTA. However, for this screening-level analysis, EPA did not identify and directly compare the individual facility discharges with the LTAs. EPA notes that the cokemaking subcategory, BAT option LTA, which includes biological treatment, is at least two orders of magnitude higher than the other subcategories (U.S. EPA, 2002).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-8. Iron and Steel Manufacturing Facility 2014 Average Direct Discharge Nitrate Concentration Data**

Data Type	Number of Data Points <sup>a</sup>	Average Nitrate Concentrations (mg/L)		
		Minimum	Median	Maximum
2014 Iron and Steel Facility DMR Data	4	0.072	1.74	34.9
2014 Iron and Steel Facility TRI Data	12	0.221	1.44	35.9

Source: *DMRLTConcOutput2014\_v1*; (ERG, 2016)

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

#### 4.1.4.3 Evaluation of Copper Discharge Concentrations

During the 2002 rulemaking, EPA evaluated discharges and calculated LTAs for copper reflecting technology bases for the proposed subcategories considered during the development of the rulemaking. For many subcategories considered, copper was either not detected or detected at low concentrations (U.S. EPA, 2002). Table 4-9 lists the technology bases and copper LTAs extracted from the Iron and Steel Manufacturing Development Document (U.S. EPA, 2002).

**Table 4-9. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA Copper Values by Subcategory**

Subcategory (Segment)	Option	Technology Basis	LTA for Copper (µg/L)
Integrated Steel (Stainless)	BAT	High-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels to reuse and treatment of blowdown with multimedia filtration.	10.1
Finishing (Carbon and Alloy)	BAT	In-process technologies include flow reduction through countercurrent rinsing, recycle of fume scrubber water, and reuse of acid. End-of-pipe treatment includes oil removal, flow equalization, hexavalent chromium reduction (for certain waste streams), metals precipitation, gravity clarification, sludge dewatering.	21.0

Source: (U.S. EPA, 2002)

BAT: Best Available Technology Economically Achievable

#### *Evaluation of Direct Discharge Copper Concentrations*

For this analysis, EPA obtained copper concentration data from 28 iron and steel manufacturing facilities: 24 from data reported on 2014 DMRs and four from facilities reporting direct releases to TRI in 2014. Table 4-10 summarizes the average iron and steel manufacturing direct discharging facility 2014 DMR and TRI copper concentration data. EPA compared the range of facility concentrations shown in Table 4-10 to the copper LTAs from the 2002 rule listed in Table 4-9. The comparison shows that the median copper concentrations from DMR and TRI are similar to the integrated steel subcategory LTA and less than the finishing subcategory LTA. However, for this screening-level analysis EPA did not identify and directly compare the individual facility discharges with the LTAs.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-10. Iron and Steel Manufacturing Facility 2014 Average Direct Discharge Copper Concentration Data**

Data Type	Number of Data Points <sup>a</sup>	Average Copper Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Iron and Steel Facility DMR Data	43	0.519	10.9	15,600 <sup>b</sup>
2014 Iron and Steel Facility TRI Data	21	1.00	10.0	180

Source: *DMRLTConcOutput2014\_v1*; (ERG, 2016)

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

<sup>b</sup> This maximum data point is an outlier. Michigan Seamless Tube reported a yearly average discharge of 15.56 mg/L (15,560 µg/L) of copper, which is several orders of magnitude higher than the other concentration data points. The next highest data point is 0.112 mg/L (112 µg/L).

### ***Evaluation of Indirect Discharge Copper Concentrations***

For this analysis, EPA obtained copper concentration data from three iron and steel manufacturing facilities reporting indirect releases to TRI in 2014. Table 4-11 summarizes these average iron and steel manufacturing facility 2014 TRI copper concentration data being sent to POTWs. EPA compared these concentrations to the LTAs from the 2002 rule listed in Table 4-9. The comparison shows that the median copper concentration is above both subcategory LTAs shown in Table 4-9. However, the concentrations listed in Table 4-11 represent concentrations from facilities reporting the highest indirect releases of copper to TRI.

**Table 4-11. Iron and Steel Manufacturing Facility 2014 Average Indirect Discharge Copper Concentration Data**

Data Type	Number of Data Points <sup>a</sup>	Copper Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Iron and Steel Facility TRI Data	3	31.0	97.5	610

Source: (ERG, 2016)

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

#### **4.1.4.4 Evaluation of Manganese Discharge Concentrations**

During the 2002 rulemaking, EPA evaluated discharges and calculated LTAs for manganese reflecting technology bases for the proposed subcategories considered during the development of the rulemaking. Table 4-12 lists the technology bases and manganese LTAs extracted from the Iron and Steel Manufacturing Development Document (U.S. EPA, 2002).

**Table 4-12. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA Manganese Values by Subcategory**

Subcategory (Segment)	Option	Technology Basis	LTA for Manganese (µg/L)
Other (Forging)	BPT	High-rate recycle, oil/water separation, and treatment of blowdown with multimedia filtration.	46.6
Finishing (Carbon and Alloy)	BAT	In-process technologies include flow reduction through countercurrent rinsing, recycle of fume scrubber water,	57.2

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-12. 2002 Iron and Steel Manufacturing Rule Technology Bases and LTA  
Manganese Values by Subcategory**

Subcategory (Segment)	Option	Technology Basis	LTA for Manganese (µg/L)
		and reuse of acid. End-of-pipe treatment includes oil removal, flow equalization, hexavalent chromium reduction (for certain waste streams), metals precipitation, gravity clarification, sludge dewatering.	
Integrated Steel (Stainless)	BAT	High-rate recycle using a scale pit with oil skimming, a roughing clarifier with oil skimming, sludge dewatering, a multimedia filter for polishing, and a cooling tower to lower the water temperature to acceptable levels to reuse and treatment of blowdown with multimedia filtration.	67.6
Other (Direct-Reduced Ironmaking (DRI))	BPT	High-rate recycle with solids removal using a classifier and clarifier, cooling, sludge dewatering, and treatment of blowdown with multimedia filtration.	1,250

Source: (U.S. EPA, 2002)

BPT: Best Practicable Control Technology Currently Available

BAT: Best Available Technology Economically Achievable

***Evaluation of Direct Discharge Manganese Concentrations***

For this analysis, EPA obtained manganese concentration data from 13 iron and steel manufacturing facilities: six from data reported on 2014 DMRs and 7 from facilities reporting direct releases to TRI in 2014. Table 4-13 summarizes the average iron and steel manufacturing direct discharging facility 2014 DMR and TRI manganese concentration data. EPA compared the range of facility concentrations shown in Table 4-13 to the manganese LTAs from the 2002 rule listed in Table 4-12. The comparison shows that the median manganese concentrations from DMR and TRI data are above three of the subcategory LTAs (other subcategory, forging segment, finishing subcategory, and integrated steel subcategory) and below the other subcategory, DRI segment LTA. However, for this screening-level analysis EPA did not identify and directly compare the individual facility discharges with the LTAs.

**Table 4-13. Iron and Steel Manufacturing Facility 2014 Average Direct Discharge  
Manganese Concentration Data**

Data Type	Number of Data Points <sup>a</sup>	Average Manganese Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Iron and Steel Facility DMR Data	17	49.0	259	1,900
2014 Iron and Steel Facility TRI Data	30	5.00	110	115,000 <sup>b</sup>

Source: *DMRLTConcOutput2014\_v1*; (ERG, 2016)

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

<sup>b</sup> These data may contain outliers. US Gary Works reported 28.5 mg/L (28,500 µg/L) of manganese and US Edgar Thompson reported 115 mg/L (115,000 µg/L), which formed the basis for their TRI release estimates in 2014. These values are several orders of magnitude greater than the rest of the manganese concentrations.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

### ***Evaluation of Indirect Discharge Manganese Concentrations***

For this analysis, EPA obtained manganese concentration data from one iron and steel manufacturing facility reporting indirect releases to TRI in 2014. Table 4-14 presents the average 2014 TRI manganese concentration data for this facility being sent to a POTW. EPA compared the concentration to the manganese LTAs from the 2002 rule listed in Table 4-12. The comparison shows that this facility’s average concentration (265 µg/L) is above three of the subcategory LTAs (Other subcategory, forging segment, finishing subcategory, and integrated steel subcategory) and below the other subcategory, DRI segment LTA, similar to the direct discharges. However, the concentration data are from a facility reporting the highest indirect releases of manganese to TRI.

**Table 4-14. Iron and Steel Manufacturing Facility 2014 Average Indirect Discharge Manganese Concentration Data**

Facility Name and Location	Average Manganese Concentration
Valbruna Slater Stainless Steel, Fort Wayne, IN	265 µg/L

Source: (ERG, 2016; Hacker, 2016)

The review of facility direct and indirect concentration data discussed above showed that most of the concentration values are above the LTAs for manganese identified during the 2002 rulemaking. EPA followed up with two additional iron and steel manufacturing facilities with manganese discharges in the 2014 DMR data to further discuss sources and treatment of manganese. The facilities confirmed that they do not use manganese in their processes and were not able to identify the source of the manganese discharges in their wastewater. Both facilities suspect the discharges may result from background concentrations in the influent water they use. Additionally, neither facility specifically adds manganese as a wastewater treatment chemical (Gill, 2016; Smith, 2016).

#### **4.1.4.5 Summary of Information Obtained from States Regarding Discharges of Lead, Nitrate, Copper, and Manganese**

EPA contacted two state permitting authorities, Indiana Department of Natural Resources (IDNR) and the West Virginia Department of Environmental Protection (WV DEP), that have a high proportion of iron and steel manufacturing facilities with DMR discharges of lead, nitrate, copper, and/or manganese to collect additional information on the development of permit limits and help inform its understanding of the discharge of these pollutants, particularly since three of these pollutants (nitrate, copper, and manganese) do not have limitations established by the Iron and Steel Manufacturing ELGs.

#### ***Lead***

The IDNR contact stated that because lead has technology-based limitations under the Iron and Steel Manufacturing ELGs, their focus is on evaluating whether a water-quality based limitation is needed by calculating a reasonable potential for lead to be present in the wastewater at a level requiring a water quality-based permit limit. The reasonable potential is determined using facility information and data provided with a permit application. The state contact indicated that lead is typically introduced at an iron and steel facility through metal finishing or

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

---

other polishing operations. The contact also stated that iron and steel manufacturing facilities use well-established technologies for removing metals in their wastewater, generally removing the metals through solids removal (Rigney, 2016).

The WV DEP contact stated that permit writers compare lead concentrations from a facility permit application to water quality standards for lead and to the Iron and Steel Manufacturing ELGs, and the most stringent limit is applied in the facility permit. Further, according to the state contact, a facility’s permit can have a mass-based lead limit to comply with the ELGs and a water quality-based concentration limit to comply with the water quality standards (Lockhart, 2016).

### ***Nitrate***

In Indiana, nitrate limits are based on water quality standards; if there is a drinking water intake downstream, the limits are based on the distance to the intake (Rigney, 2016).

In West Virginia, if the permit application contains nitrate discharges, the state will calculate a reasonable potential to discharge and apply the water quality standard (10 mg/L). If the discharge is very high, the state will set a performance-based limit for nitrate (Lockhart, 2016).

### ***Copper***

For both states, copper permit limits are based on water quality standards (Lockhart, 2016; Rigney, 2016). In Indiana, the state establishes water-quality-based effluent limits for copper using the tables of water quality criteria under 327 IAC 2 (Indiana General Assembly, 2016). The state contact indicated that solids removal removes metals from wastewater and the efficiency of removal is correlated to the pH of the system (Rigney, 2016).

### ***Manganese***

In Indiana, the discharge concentration data are compared to the water quality criteria (if there are any for the pollutant) to determine a reasonable potential to discharge, and the state sets a limit if needed. The Indiana state contact indicated that manganese is not typically added at iron and steel manufacturing facilities; it is a component of coal and could be a byproduct of coal combustion and other burnings (Rigney, 2016). In West Virginia, manganese permit limits are based on water quality standards (Lockhart, 2016).

#### **4.1.4.6 Evaluation of Available Treatment Technology Performance Data for Lead, Nitrate, Copper, and Manganese**

EPA reviewed recent literature compiled in the IWTT Database to identify emerging treatment technologies that are being evaluated and/or implemented within the iron and steel manufacturing industry, or that are being evaluated and/or implemented in other industries, specifically for the removal of lead, nitrate, copper, and manganese (for more information on the IWTT Database, see Section 6.2 of this report). EPA identified 21 articles that described removal of these pollutants, one of which was specific to the iron and steel manufacturing industry. Table 4-17, at the end of this subsection, summarizes these systems and their treatment effectiveness.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1—Iron and Steel Manufacturing (40 CFR Part 420)*

According to information collected during the 2002 Iron and Steel Manufacturing rulemaking, the industry extensively uses physical/chemical treatment technologies. Physical/chemical treatment can effectively remove pollutants such as TSS, oil and grease, heavy organics (tars), ammonia, cyanide, and metals. EPA also identified biological treatment technologies used in the industry, particularly for the cokemaking sector, targeted for removal of organics and nutrients (U.S. EPA, 2002). Table 4-15 lists the general chemical/physical and biological treatment technologies EPA identified in place in the iron and steel manufacturing industry during the 2002 rulemaking.

**Table 4-15. Chemical/Physical and Biological Treatment Technologies Used by the Iron and Steel Manufacturing Industry in 2002**

Treatment Technology Type	Applicable Technologies
Chemical/Physical	<ul style="list-style-type: none"> <li>• Equalization</li> <li>• Tar removal</li> <li>• Free and fixed ammonia distillation (stripping)</li> <li>• Cooling towers</li> <li>• Shell-and-tube heat exchangers</li> <li>• Alkaline chlorination/breakpoint chlorination</li> <li>• Cyanide precipitation</li> <li>• Ozone oxidation</li> <li>• Gravity flotation</li> <li>• Oil/water separation</li> <li>• Chemical emulsion breaking and dissolved air flotation</li> <li>• Ultrafiltration</li> <li>• Carbon dioxide injection</li> <li>• Hexavalent chromium reduction</li> <li>• Chemical precipitation</li> <li>• Ion exchange</li> <li>• Scale pits with oil skimming</li> <li>• Classifiers</li> <li>• Clarification/sedimentation</li> <li>• Microfiltration</li> <li>• Multimedia filtration</li> <li>• Granular activated carbon</li> </ul>
Biological	<ul style="list-style-type: none"> <li>• Biological nitrification using conventional activated sludge</li> <li>• Biological nitrification using sequencing batch reactors (SBRs)</li> <li>• Biological nitrification using attached growth</li> <li>• Biological denitrification</li> </ul>

Source: (U.S. EPA, 2002)

EPA identified in IWTT a variety of wastewater treatment technologies that have recently been investigated as treatments for lead, nitrate, copper, and manganese, summarized in Table 4-17, though most are pilot-scale. Much of the treatment performance data for these technologies address metal removals, and, except for seven systems, achieve removal rates greater than 82 percent. Effluent concentrations for lead, nitrate, copper, and manganese were not consistent across the identified studies.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

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Table 4-16 summarizes the effluent concentrations from the studies identified in IWTT (detailed in Table 4-17) and the range of LTA concentrations considered during the 2002 Iron and Steel Manufacturing rulemaking for lead, nitrate, copper, and manganese.

As shown in Table 4-16 and Table 4-17, effluent concentrations of lead identified from studies in IWTT are generally less than, but on the same order of magnitude and as the range of the LTA lead concentrations identified for the 2002 rulemaking. Two of the four studies listed in Table 4-17 show concentrations lower than the median lead concentrations identified from the 2014 DMR and TRI direct discharge data (0.0025 mg/L and 0.00282 mg/L, respectively), however, EPA notes that the performance data were not specific to the treatment of iron and steel manufacturing wastewater.

Effluent concentrations of nitrate from studies in IWTT are generally of the same order of magnitude as the range of LTA nitrate concentrations identified for the 2002 rulemaking for all but the cokemaking subcategory, BAT option, which is two orders of magnitude higher than the other subcategory LTAs. Similarly, a comparison of the 2002 LTA range (without the cokemaking subcategory, BAT option) and the concentrations achieved in the IWTT studies showed one study achieved concentrations below the LTA range. In addition, several of the studies listed in Table 4-17 show concentrations lower than the median nitrate concentrations identified from the 2014 DMR and TRI direct discharge data (1.74 mg/L and 1.44 mg/L, respectively), however, EPA notes that the performance data were not specific to the treatment of iron and steel manufacturing wastewater.

Effluent concentrations of copper from studies in IWTT are generally of the same order of magnitude as the range of the LTA copper concentrations identified for the 2002 rulemaking. Two studies achieved copper concentrations below the copper LTA range. In addition, several of the studies listed in Table 4-17 show concentrations below the median copper concentrations identified from the 2014 DMR and TRI direct discharge data (0.0109 mg/L and 0.01 mg/L, respectively). EPA notes that only one of the studies in IWTT was specific to the treatment of iron and steel manufacturing wastewater and the reported effluent concentration of copper was the highest among the studies in IWTT (<2 mg/L) and two orders of magnitude higher than the LTAs identified for the 2002 rulemaking and DMR and TRI concentrations.

Of the treatment technology performance data for manganese removal in IWTT, only one study showed effluent manganese concentrations lower than the range of LTA manganese concentrations identified for the 2002 rulemaking, however, it was applied to petroleum refinery wastewater and was pilot scale. In general, manganese effluent concentrations observed from the studies in IWTT are also higher than, or the same order of magnitude as the median manganese concentrations identified from the 2014 DMR and TRI direct discharge data (0.259 mg/L and 0.11 mg/L, respectively), however, EPA notes the performance data were not specific to the treatment of iron and steel manufacturing wastewater.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1—Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-16. Treatment Technology Performance Data and LTA Values for Lead, Nitrate, Copper, and Manganese**

Parameter	Lead (mg/L)	Nitrate (mg/L)	Copper (mg/L)	Manganese (mg/L)
<b>LTA Concentrations by Subcategory (Segment)</b>				
Non-Integrated Steelmaking and Hot Forming (Carbon/Alloy)	0.00643	-	-	-
Finishing (Carbon/Alloy)	0.00754	0.114	0.021	0.0572
Integrated and Stand-Alone Hot Forming (Carbon/Alloy)	0.0141	-	-	-
Integrated and Stand-Alone Hot Forming (Stainless)	0.0693	1.95	0.0101	0.0676
Cokemaking (Byproduct Recovery), PSES Option 1	-	0.831	-	-
Cokemaking (Byproduct Recovery), BAT Option 1	-	114	-	-
Other (Forging)	-	-	-	0.0466
Other (Direct-Reduced Ironmaking (DRI))	-	-	-	1.25
<b>Range of IWTT Concentration Data shown in Table 4-17</b>				
Minimum Effluent Concentration	< 0.001	0.01	0.00223	< 0.01
Maximum Effluent Concentration	0.0528	2.8	< 2.0	1.77

Source: (U.S. EPA, 2002)

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-17. Summary of Wastewater Treatment Technologies for Lead, Nitrate, Copper, and Manganese**

Parameter	Wastewater Treatment Technology (Order of Unit Processes)	Effluent Concentration (mg/L)	Percent Removal	Industry	Treatment Scale	Reference
Lead	Membrane bioreactor	0.001	76.7%	Metal Finishing	Pilot	(Buckles, et al., 2003)
	Bag and cartridge filtration, oil/water separation, flow equalization, membrane filtration	0.004	95.0%		Pilot	(Pugh, et al., 2014)
	Membrane bioreactor, Aeration	0.0528	96.7%	Ore Mining and Dressing	Pilot	(Progress, et al., 2012)
	Mechanical pre-treatment, flow equalization, oil/water separation, membrane bioreactor, adsorptive media	< 0.001	>76.7%	Transportation Equipment Cleaning	Full	(Buckles, et al., 2007)
Nitrate	Adsorptive media	2	50.0%	Petroleum Refining	Full	(Hayes & Sherwood, 2012)
	Membrane filtration, ion exchange, and reverse osmosis	2.8	88.8%		Pilot	(Ginzburg & Cansino, 2009)
	Aerobic fixed film biological treatment	NR	< 100%	Coal Mining	Full	(Reinsel, 2010)
	Flow equalization, membrane filtration, and reverse osmosis	0.42	97.5%	Ferroalloy Manufacturing	Pilot	(Benito & Ruiz, 2002)
Nitrate (as N)	Anaerobic fixed film biological treatment and membrane filtration	0.01	99.9%	Coal Mining	Pilot	(Munirathinam, et al., 2011)
	Anaerobic fixed film biological treatment and moving bed bioreactor	0.7	97.7%		Pilot	(Gay, et al., 2012)
	Ozonation	1.8	10.0%	Textile Mills	Pilot	(Somensi, et al., 2010)
	Granular-media filtration, membrane filtration, and reverse osmosis	0.73	51.3%	Electrical and Electronic Components	Pilot	(Huang, et al., 2011)
Copper	Electrocoagulation	NR	95.0%	Electrical and Electronic Components	Pilot	(Kim, et al., 2012)
	Flow equalization, membrane filtration, and reverse osmosis	0.12	93.3%	Ferroalloy Manufacturing	Pilot	(Benito & Ruiz, 2002)
	Membrane bioreactor	0.0105	70.5%	Metal Finishing	Pilot	(Buckles, et al., 2003)
	Bag and cartridge filtration, oil/water separation, flow equalization, and membrane filtration	< 0.025	> 95.0%		Pilot	(Pugh, et al., 2014)

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-17. Summary of Wastewater Treatment Technologies for Lead, Nitrate, Copper, and Manganese**

Parameter	Wastewater Treatment Technology (Order of Unit Processes)	Effluent Concentration (mg/L)	Percent Removal	Industry	Treatment Scale	Reference
	Biologically active filters	NR	95.0%	Nonferrous Metals Manufacturing	Pilot	(Diels, et al., 2003)
	Membrane bioreactor and aeration	0.0042	99.3%	Ore Mining and Dressing	Pilot	(Progress, et al., 2012)
	Adsorptive media	0.00223	96.8%	Steam Electric Power Generating	Pilot	(Aldave & Buday, 2011)
	Mechanical pre-treatment, flow equalization, oil/water separation, membrane bioreactor, and adsorptive media	0.011	69.1%	Transportation Equipment Cleaning	Full	(Buckles, et al., 2007)
Copper, total	Flow equalization, chemical precipitation, clarification, (repeated in sequence) granular-media filtration, granular activated carbon unit, ion exchange, and reverse osmosis	< 0.02	> 99.5%	Aluminum Forming	Full	(Patrick, et al., 2008)
	Chemical precipitation, aeration, and ballasted clarification	< 2	> 96.4%	Iron and Steel Manufacturing	Pilot	(Kessler, 2002)
Manganese	Aerobic fixed film biological treatment, chemical precipitation, and powdered activated carbon	0.15	53.1%	Metal Finishing	Pilot	(Ahmad, et al., 2010)
	Chemical precipitation, dissolved air flotation, and granular-media filtration	0.23	98.6%	Ore Mining and Dressing	Pilot	(Colic & Hogan, 2012)
	Membrane bioreactor and aeration	1.77	82.0%		Pilot	(Progress, et al., 2012)
	Constructed wetlands	NR	92.5%	Steam Electric Power Generating	Pilot	(Morrison, et al., 2011)
	Membrane filtration, ion exchange, and reverse osmosis	< 0.01	> 83.3%	Petroleum Refining	Pilot	(Ginzburg & Cansino, 2009)

NR – Not Reported

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

#### **4.1.5 Iron and Steel Manufacturing Category NPRI Analysis**

EPA evaluated the utility of using data from Canada’s NPRI to identify potential additional pollutants that may be present in industrial wastewater discharges from facilities in the U.S., as indicated by their presence in industrial wastewater discharges from facilities in Canada. Section 2.2 of this report provides a general overview of the NPRI analyses and methodology. This section presents EPA’s review of the NPRI data specific to the Iron and Steel Manufacturing Category.

##### **4.1.5.1 NPRI Analysis Overview**

EPA compared water release data in TRI to data reported in Canada’s NPRI for the Iron and Steel Manufacturing Category to identify the pollutants reported in NPRI, but not captured in the TRI. For those pollutants, EPA compared the reporting requirements between NPRI and TRI to understand the impact of any reporting differences (e.g., are the thresholds for reporting similar, do groups of reported chemicals include the same set of individual compounds, etc.) and further evaluated the potential for releases of these pollutants in the U.S.

For this analysis, EPA evaluated 2013 TRI and NPRI data, the most recent data available in both datasets at the time of review. EPA processed the data as described in Section 2.2 to obtain the relevant industry category, pollutant names, facility counts, and water releases for each of the datasets. For facilities associated with the Iron and Steel Manufacturing Category, EPA compared the list of pollutants with water releases reported to NPRI and TRI.

In 2013, 19 Canadian iron and steel manufacturers reported water release data for 45 pollutants to NPRI, while 215 U.S. iron and steel manufacturers reported water release data for 39 pollutants to TRI. As shown in Table 4-18, EPA identified 13 pollutants reported to NPRI that were not reported to TRI by iron and steel manufacturing facilities in 2013. Seven of the 13 pollutants are not included on the EPCRA Section 313 Chemical List for 2013 (2013 List of TRI Chemicals); therefore, facilities are not required to report releases for these pollutants (U.S. EPA, 2014b).

**Table 4-18. Pollutants Reported by Iron and Steel Manufacturing Facilities to 2013 NPRI but not to 2013 TRI**

<b>Pollutant Name</b>	<b>On 2013 List of TRI Chemicals<sup>a</sup></b>	<b>Number of NPRI Iron and Steel Manufacturing Facilities Reporting Pollutant Release to Water</b>	<b>Percentage of all NPRI Iron and Steel Manufacturing Facilities Reporting Water Release</b>
Acenaphthene – PAH	N	1	5%
Acenaphthylene – PAH	N	2	11%
Aluminum (fume or dust)	Y	1	5%
Benzo(e)pyrene – PAH	N	1	5%
Benzo(g,h,i)perylene – PAH	Y	3	16%
Calcium fluoride	N	1	5%
Chlorine	Y <sup>b</sup>	1	5%
Fluorene – PAH	N	2	11%
Hydrochloric acid	Y	2	11%

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

**Table 4-18. Pollutants Reported by Iron and Steel Manufacturing Facilities to 2013 NPRI but not to 2013 TRI**

<b>Pollutant Name</b>	<b>On 2013 List of TRI Chemicals<sup>a</sup></b>	<b>Number of NPRI Iron and Steel Manufacturing Facilities Reporting Pollutant Release to Water</b>	<b>Percentage of all NPRI Iron and Steel Manufacturing Facilities Reporting Water Release</b>
Perylene - PAH	N	2	11%
Phosphorus (total)	N <sup>c</sup>	6	32%
Pyrene - PAH	N	3	16%
Sulfuric acid	Y	2	11%

Source: *NPRICompare2013, TRIOutput2013\_v1*, (U.S. EPA, 2014b)

PAH: Polycyclic Aromatic Hydrocarbon

a Refers to pollutants included in the 2013 List of TRI Chemicals, regardless of whether water releases were reported for the pollutant.

b Chlorine is in gaseous form, and not expected to be released to water under typical conditions (U.S. EPA, 1998).

c The 2013 List of TRI Chemicals only includes Phosphorus (yellow or white). Yellow and white phosphorus, both allotropes of elemental phosphorus, are hazardous pollutants that spontaneously ignite in air. During the 2006 Annual Review, EPA identified that facilities were incorrectly reporting discharges of total phosphorus (i.e., the phosphorus portion of phosphorus-containing compounds) as phosphorus (yellow or white) (U.S. EPA, 2006). Therefore, EPA concluded that it was appropriate to exclude all phosphorus (yellow or white) discharges reported to TRI, and has made such adjustments to the data, beginning with the 2011 Annual Review (U.S. EPA, 2012). Total phosphorus (as reported in NPRI) is not included in the current List of TRI chemicals (for reporting year 2015).

#### **4.1.5.2 NPRI Pollutant Analysis**

EPA identified 13 pollutants reported to NPRI in 2013 that were not reported to TRI, over half of which are polycyclic aromatic hydrocarbons. All but phosphorus were reported to NPRI by less than 20 percent of reporting facilities. Because phosphorus was reported to NPRI by 32 percent of facilities, EPA performed a more in-depth analysis of this pollutant.

No iron and steel manufacturing facilities reported total phosphorus releases to TRI in 2013 because total phosphorus is not a TRI-listed pollutant. However, TRI does include one form of phosphorus on the 2013 List of TRI Chemicals, known as yellow or white phosphorus (U.S. EPA, 2014b). Historically, as part of its ELG planning review process, EPA excludes yellow or white phosphorus reported to TRI from its analyses because this elemental form of phosphorus is insoluble in water and is not the same form of phosphorus commonly measured in wastewater (U.S. EPA, 2012). According to NPRI reporting guidance, total phosphorus does not include yellow or white phosphorus; NPRI includes yellow or white phosphorus as a separate pollutant (Environment Canada, 2015).

EPA compared the magnitude of the phosphorous releases reported in NPRI to available 2013 DMR data for phosphorous. The 2013 NPRI total phosphorus releases ranged from 66.1 pounds to 4,880 pounds, as shown in Table 4-19. The total phosphorus discharges reported by the top ten discharging iron and steel manufacturing facilities in DMR range from 77.3 pounds to 13,100 pounds, as shown in Table 4-20. These top ten facilities account for over 99 percent of the total 2013 DMR total phosphorus discharges reported by iron and steel manufacturing facilities. In general, total phosphorus releases reported by iron and steel manufacturing facilities to NPRI in Canada are similar to the total phosphorus discharges reported by iron and steel

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

manufacturing facilities on DMRs in the U.S., with the exception of the top two facilities reporting total phosphorus discharges on DMRs, which have much higher discharges.

Though several facilities report total phosphorus discharges on DMRs, phosphorus does not have limitations in the Iron and Steel Manufacturing ELGs. In addition, EPA has not previously reviewed total phosphorus discharges for the iron and steel manufacturing industry as part of recent ELG planning reviews. Total phosphorus does not have an associated toxic weighting factor and subsequently does not appear in EPA’s TRA. See Section 2 of EPA’s 2015 Annual Review Report for more information on toxic weighting factors and EPA’s TRA (U.S. EPA, 2016a).

**Table 4-19. Top 2013 Iron and Steel Manufacturing Facilities Reporting Total Phosphorus Releases to NPRI**

Facility Name	Facility Location	Direct Pounds of Pollutant Released	Indirect Pounds of Pollutant Released	Total Pounds of Pollutant Released
Dofasco Hamilton	Hamilton, ON	1,520	3,370	4,880
Hamilton Works	Hamilton, ON	1,350	832	2,180
Gerdau Ameristeel Corporation, Whitby Mill	Whitby, ON	0	379	379
Evraz Inc NA Canada - Regina Facilities	Regina, SK	0	101	101
Sivaco Ontario	Ingersoll, ON	0	95.2	95.2
Rio Tinto Fer Et Titane Inc. Complexe De Sorel-Tracy	Sorel-Tracy, QC	66.1	0	66.1
<b>Total</b>		<b>2,930</b>	<b>4,780</b>	<b>7,710</b>

Source: (Environment Canada, 2014).

Note: Facilities report pounds of pollutant released directly to surface waters or indirectly to POTWs.

**Table 4-20. Top 2013 Iron and Steel Manufacturing Facilities Reporting Total Phosphorus Discharges on DMRs**

Facility Name	Facility Location	Pounds of Pollutant Discharged
Mittal Steel Usa Weirton Inc	Weirton, WV	13,100
Severstal Wheeling Inc – Follansbee	Follansbee, WV	12,200
U.S. Steel Corporation - Fairfield Works	Fairfield, AL	5,710
Us Steel Fairless Hills Works	Fairless Hills, PA	2,820
Nucor Steel	Crawfordsville, IN	2,060
Sterling Steel Co LLC	Sterling, IL	1,800
Standard Steel LLC	Burnham, PA	691
Crucible Industries LLC	Solvay, NY	687
USS Gary Works	Gary, IN	116
Michigan Seamless Tube LLC	South Lyon, MI	77.3
All other Iron and Steel Manufacturing dischargers of total phosphorus (three additional facilities)		70.5
<b>Total</b>		<b>39,300</b>

Source: *DMRLTOutput2013\_v1*

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

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#### **4.1.6 Summary of the Iron and Steel Manufacturing Category Review**

From its evaluation of lead, nitrate, copper, and manganese discharges, EPA learned:

- *Lead.* EPA identified a large number of iron and steel manufacturing facilities with reported lead discharges in the 2013 and 2014 DMR and TRI data. The Iron and Steel Manufacturing ELGs regulate lead in eight of 13 subcategories. EPA compared facility concentration data in DMR and provided by facilities reporting to TRI to concentrations achieved by the technologies evaluated in the 2002 Iron and Steel Manufacturing rulemaking. The data show that the direct discharge concentrations of lead from this category are below the concentrations achieved by the technologies evaluated for the 2002 rulemaking. Facility-specific concentration data for indirect dischargers are above most of the LTAs for lead evaluated in the 2002 rulemaking; however, they represent concentrations from facilities reporting the highest indirect releases of lead to TRI.

Discussions with one state permitting authority indicated that the technologies for removing metals at iron and steel manufacturing facilities are well established and that they are generally removed through solids removal. EPA’s review of performance data in the IWTT Database identified several technologies that effectively remove lead (not specific to iron and steel manufacturing), achieving effluent concentrations lower than the median 2014 DMR and TRI lead concentrations and generally less than, but on the same order of magnitude as the concentrations achieved by the technologies considered during the 2002 Iron and Steel Manufacturing rulemaking.

- *Nitrate.* The Iron and Steel Manufacturing ELGs do not regulate nitrate; however, EPA identified a large number of facilities with reported nitrate releases in the 2013 and 2014 TRI data. The review of facility concentration data in DMR and data provided by facilities reporting to TRI demonstrated that, in general, the nitrate direct discharge concentration values are above, but on the same order of magnitude as the concentrations achieved by most of the technologies considered in EPA’s 2002 rulemaking for all but the cokemaking subcategory, BAT option, which is two orders of magnitude higher than the other subcategory LTAs. Only a few facilities report indirect releases of nitrate to TRI, and EPA was unable to obtain nitrate concentration data from these dischargers.

EPA’s review of performance data in the IWTT Database identified several technologies achieving concentrations generally of the same order of magnitude as the range of LTA nitrate concentrations identified for the 2002 rulemaking for all but the cokemaking subcategory, BAT option. In addition, several of the studies show concentrations generally of the same order of magnitude but lower than the median nitrate concentrations identified from the 2014 DMR and TRI direct discharge data

- *Copper.* The Iron and Steel Manufacturing ELGs do not regulate copper; however, EPA identified a large number of facilities with reported copper releases in the 2013 and 2014 TRI data. The review of available facility concentration data in DMR and data provided by facilities reporting to TRI demonstrated that the direct discharges of copper are below, but on the same order of magnitude as the concentrations achieved

4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)

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by the technologies considered during the 2002 rulemaking. The indirect discharge median concentration is above, but on the same order of magnitude as the concentrations achieved by the technologies considered during the 2002 rulemaking. However, the indirect data represent concentrations from facilities reporting the highest indirect releases of copper to TRI.

Effluent concentrations of copper from studies in IWTT are generally of the same order of magnitude as the range of the LTA copper concentrations identified for the 2002 rulemaking. Two studies achieved copper concentrations below the copper LTA range. In addition, several of the studies show concentrations below the median copper concentrations identified from the 2014 DMR and TRI direct discharge data.

- *Manganese.* The Iron and Steel Manufacturing ELGs do not regulate manganese; however, EPA identified a large number of facilities with releases in the 2013 and 2014 TRI data. During the 2002 rulemaking, EPA ultimately decided not to establish manganese limitations because manganese may be used as a treatment chemical.

The review of facility concentration data in DMR and data provided by facilities reporting direct and/or indirect releases to TRI demonstrated that the median concentration values are above most of the concentrations achieved by the technologies considered during the 2002 rulemaking. EPA followed up with two additional iron and steel manufacturing facilities; neither facility confirmed the source of manganese in their wastewater but suspect the discharges may result from background concentrations in the influent water. One state contact indicated that manganese is not contained in feedstock at iron and steel manufacturing facilities, but rather is a component of coal and could be a byproduct of burning coal and other substances. Of the treatment technology performance data for manganese removal in IWTT, only one study showed effluent manganese concentrations lower than the range of LTA manganese concentrations identified for the 2002 rulemaking, however, it was applied to petroleum refinery wastewater and was pilot scale. In general, manganese effluent concentrations observed from the studies in IWTT are also higher than, or the same order of magnitude as the median manganese concentrations identified from the 2014 DMR and TRI direct discharge data.

- EPA’s review of NPRI identified 13 pollutants that were reported in NPRI in 2013 but not to TRI, over half of which are polycyclic aromatic hydrocarbons. EPA focused its review on total phosphorus, as it was the only pollutant reported by more than 20 percent of the iron and steel manufacturing facilities to the 2013 NPRI. TRI does not require facilities to report discharges of total phosphorus, therefore, EPA compared the magnitude of the 2013 NPRI discharges to total phosphorus discharges reported in 2013 DMR data. In general, the magnitude of total phosphorus releases in the 2013 NPRI is similar to the 2013 DMR total phosphorus loadings, with the exception of the top two discharges in the U.S., which are much higher.

#### 4.1.7 Iron and Steel Manufacturing Category References

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*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)

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*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.1–Iron and Steel Manufacturing (40 CFR Part 420)*

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*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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## **4.2 Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)**

As part of the 2015 Annual Review, EPA initiated a preliminary category review of the Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) Category because it ranked high, in terms of toxic-weighted pound equivalents (TWPE), in the final 2015 toxicity rankings analysis (TRA) (U.S. EPA, 2016a). EPA previously reviewed discharges from this category as part of the 2004 through 2011, and 2013 Annual Reviews (U.S. EPA, 2004, 2005a, 2005b, 2006, 2007, 2008, 2009a, 2011a, 2012, 2014a). EPA conducted a preliminary study of carbon disulfide discharges from cellulose products manufacturers in 2011 (U.S. EPA, 2011b) and reviewed discharges from the chlorinated hydrocarbon manufacturing segment of the OCPSF Category as part of the Chlorine and Chlorinated Hydrocarbons (CCH) effluent guidelines rulemaking.<sup>17</sup>

From its 2015 TRA and preliminary category reviews, EPA decided that the OCPSF Category warrants further review, specifically related to the discharges of total residual chlorine and nitrate and nitrate compounds (nitrate) (U.S. EPA, 2016b). The OCPSF Category effluent limitations guidelines and standards (ELGs) do not regulate either of these pollutants. As part of this review, EPA further evaluated the discharges of these pollutants to:

- Understand the process operations at OCPSF facilities that generate the pollutants and how the facilities are currently managing their wastewater.
- Understand how permitting authorities currently regulate discharges of these pollutants.
- Decide if the concentrations of total residual chlorine or nitrate in effluent discharges are present at a level that could be reduced by further treatment.
- Identify advances in industrial wastewater treatment technology performance for reducing discharges of the pollutants.
- Identify additional pollutants potentially present in facility industrial wastewater discharges in the U.S., not currently captured in discharge monitoring report (DMR) data or Toxics Release Inventory (TRI) data.

Section 4.2.1 provides a background of the OCPSF Category (40 CFR Part 414), and Section 4.2.2 provides a summary of the results of the previous ELG planning review related to the OCPSF Category. Sections 4.2.3 through 4.2.6 present EPA's current review approach and evaluation of the OCPSF Category, including results from EPA's continued review of the top pollutants in the category, evaluation of available treatment technology performance, and the results of the additional pollutant analysis. Section 4.2.7 summarizes EPA's current review of the OCPSF Category.

### **4.2.1 *OCPSF Category Background***

The OCPSF Category includes more than 1,000 chemical manufacturing facilities (identified in 1987 as part of the rulemaking for this category), producing over 25,000 end products, such as benzene, toluene, polypropylene, polyvinyl chloride, chlorinated solvents, rubber precursors, rayon, nylon, and polyester. The OCPSF industry is large and diverse, and

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<sup>17</sup> Based on the information collected during the rulemaking, EPA proposed to delist the CCH manufacturing segments and discontinue the rulemaking in 2012.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

many plants are highly complex. Some plants produce chemicals in large volumes through continuous chemical processes, while others produce only small volumes of specialty chemicals through batch chemical processes (U.S. EPA, 2016c). The following subsections present an overview of the OCPSF Category ELGs and their applicability.

#### 4.2.1.1 OCPSF ELGs

EPA promulgated ELGs for the OCPSF Category on November 5, 1987. The OCPSF Category consists of seven subcategories defined by the manufacture of different products, and three subcategories based on the type of facility discharge, as shown in Table 4-21, with corresponding basis for applicability.

**Table 4-21. OCPSF ELGs Subcategories**

Subpart	Subcategory Title	Basis for ELG Applicability
B	Rayon Fibers	Cellulosic manmade fiber (Rayon) manufactured by the Viscose process.
C	Other Fibers	All other synthetic fibers (except Rayon) including, but not limited to, products listed in Section 414.30.
D	Thermoplastic Resins	Any plastic product classified as a thermoplastic resin including, but not limited to, products listed in Section 414.40.
E	Thermosetting Resins	Any plastic product classified as a thermosetting resin including, but not limited to, products listed in Section 414.50.
F	Commodity Organic Chemicals	Commodity organic chemicals and commodity organic chemical groups including, but not limited to, products listed in Section 414.60.
G	Bulk Organic Chemicals	Bulk organic chemicals and bulk organic chemical groups including, but not limited to, products listed in Section 414.70.
H	Specialty Organic Chemicals	All other organic chemicals and organic chemical groups including, but not limited to, products listed in the OCPSF Development Document (Vol. II, Appendix II-A, Table VII).
I	Direct Discharge Point Sources That Use End-of-Pipe-Biological Treatment	Process wastewater discharges resulting from the manufacture of the OCPSF products and product groups from any point source that uses end-of-pipe biological treatment or installs end-of-pipe biological treatment to comply with BPT effluent limitations.
J	Direct Discharge Point Sources That Do Not Use End-of-Pipe-Biological Treatment	Process wastewater discharges resulting from the manufacture of the OCPSF products and product groups from any point source that does not use end-of-pipe biological treatment and does not install end-of-pipe biological treatment to comply with Best Practicable Control Technology Currently Available (BPT) effluent limitations.
K	Indirect Discharge Point Sources	Process wastewater discharges resulting from the manufacture of the OCPSF products and product groups from any indirect discharge point source.

Source: (U.S. EPA, 2005b).

#### 4.2.1.2 OCPSF Category Applicability

The OCPSF regulation applies to process wastewater discharges resulting from the manufacture of the products or product groups covered in subparts B through H. For the purpose of its annual reviews, EPA considers the following 14 North American Industry Classification System (NAICS) codes and 10 Standard Industrial Classification (SIC) codes to be part of the OCPSF Category, identified from the NAICS-Point Source Category (NAICS-PSC) and SIC-

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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PSC crosswalks developed for the 304m Annual Review process (U.S. EPA, 2009b). The 14 NAICS codes are:

- NAICS 325110: Petrochemical Manufacturing
- NAICS 325132: Synthetic Organic Dye and Pigment Manufacturing
- NAICS 325192: Cyclic Crude and Intermediate Manufacturing
- NAICS 325193: Ethyl Alcohol Manufacturing
- NAICS 325199: All Other Basic Organic Chemical Manufacturing
- NAICS 325211: Plastics Material and Resin Manufacturing
- NAICS 325221: Cellulosic Organic Fiber Manufacturing
- NAICS 325222: Noncellulosic Organic Fiber Manufacturing
- NAICS 325520: Adhesive Manufacturing
- NAICS 325612: Polish and Other Sanitation Good Manufacturing
- NAICS 325620: Toilet Preparation Manufacturing
- NAICS 325998: All Other Miscellaneous Chemical Product and Preparation Manufacturing
- NAICS 424690: Other Chemical and Allied Products Merchant Wholesalers
- NAICS 562920: Materials Recovery Facilities

The ten SIC codes include:

- SIC 2821: Plastics Materials, Synthetic and Resins, and Nonvulcanizable Elastomers
- SIC 2823: Cellulosic Man-Made Fibers
- SIC 2824: Manmade Organic Fibers, Except Cellulosic
- SIC 2842: Specialty Cleaning, Polishing, and Sanitation Preparation
- SIC 2844: Perfumes, Cosmetics, and Other Toilet Preparations (except toothpaste, gel, and dentifrice powders)
- SIC 2865: Cyclic Crudes and Intermediates, Dyes, and Organic Pigments
- SIC 2869: Industrial Organic Chemicals, NEC (cyclopropane, diethylcyclohexane, naphthalene sulfonic acid)
- SIC 2891: Adhesives and Sealants
- SIC 2899: Chemicals and Chemical Preparations, NEC (table salt)
- SIC 5169: Chemicals and Allied Products, NEC (merchant wholesalers)

Additionally, wastewater generated by facilities in the following NAICS codes may be regulated under multiple categories, including OCPSF.<sup>18</sup>

- NAICS 311999: All Other Miscellaneous Food Manufacturing
- NAICS 324199: All Other Petroleum and Coal Products Manufacturing

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<sup>18</sup> As part of the 2010 Annual Review, EPA reviewed available information about pollutant loads and manufacturing operations at facilities reporting these NAICS codes and concluded that the OCPSF ELGs apply to some of the facilities in these NAICS codes (U.S. EPA, 2011b).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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- NAICS 325120: Industrial Gas Manufacturing
- NAICS 325188: All Other Basic Inorganic Chemical Manufacturing
- NAICS 325510: Paint and Coating Manufacturing
- NAICS 325611: Soap and Other Detergent Manufacturing
- NAICS 326199: All Other Plastics Product Manufacturing
- NAICS 339999: All Other Miscellaneous Manufacturing

The OCPSF ELGs applied to approximately 1,000 facilities at the time of promulgation in 1987. Approximately 320 of the 1,000 facilities discharged to surface waters, while approximately 420 facilities discharged to publicly owned treatment works (POTWs). EPA identified the remaining facilities as either zero dischargers, alternative dischargers, or discharge status unknown (U.S. EPA, 1987).

EPA identified 649 OCPSF facilities reporting water releases to TRI in 2014, with 201 facilities reporting direct releases to surface waters, 391 facilities reporting indirect releases to POTWs, and 57 facilities reporting both direct and indirect releases (*TRILTOOutput2014\_v1*). EPA identified 273 OCPSF facilities that submitted 2014 DMR data to the Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES) (*DMRLTOOutput2014\_v1*). While these numbers appear to show a decline in the number of OCPSF facilities discharging since the 1980s, due to the limitations of the DMR and TRI datasets, EPA does not have an exact count of how many facilities currently are subject to the OCPSF ELGs. See Section 2.1 for a discussion on the limitations of DMR and TRI data.

#### ***4.2.2 Summary of the Results of the 2015 Annual Review for the OCPSF Category***

During the 2015 Annual Review, EPA identified DMR discharges of total residual chlorine and TRI releases of nitrate for further review. The paragraphs below summarize the results of EPA’s previous review regarding these two pollutants (U.S. EPA, 2016b).

- *Total residual chlorine.* In 2013, 97 facilities reported total residual chlorine discharges, out of a total of 280 OCPSF facilities reporting 2013 DMR data. Four facilities account for over 60 percent of those discharges. EPA reviewed the DMR data for these four facilities and all four met their permit limits in 2013; however, the total residual chlorine limit for three of the facilities was a minimum total residual chlorine concentration limit. EPA did not conduct a facility-level review of the total residual chlorine discharges for the remaining 93 facilities because no single facility contributed more than 5,000 TWPE. However, due to the number of facilities with total residual chlorine discharges in the 2013 DMR data, and an indication that three of the top four facilities reporting total residual chlorine discharges only have minimum total residual chlorine limits in their permits, EPA concluded that further investigation of this pollutant is appropriate to evaluate whether discharges are industry-wide and present at a level substantial enough for further treatment.
- *Nitrate.* In 2013, 121 facilities reported releases of nitrate to TRI out of a total of 651 OCPSF facilities reporting 2013 TRI releases; two facilities account for 38 percent of those releases. EPA confirmed that both facilities base their nitrate TRI releases on monitoring data. One facility’s nitrate releases have remained similar from 2010

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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through 2013, while the other facility’s nitrate releases have decreased from 2010 through 2013. EPA did not conduct a facility-level review of the remaining 119 facilities reporting TRI nitrate releases in 2013. However, due to the number of facilities with nitrate releases in the TRI data, EPA concluded that further investigation of nitrate is appropriate to evaluate whether discharges are industry-wide and present at a level substantial enough for further treatment.

#### **4.2.3 Introduction to EPA’s Current Evaluation of Specific Pollutants in the OCPSF Category**

For the current review, EPA evaluated the discharges of total residual chlorine and nitrate to satisfy the objectives outlined above in Section 4.2. The OCPSF ELGs do not regulate either of these pollutants. Specifically, EPA:

- Evaluated available 2014 DMR and TRI data<sup>19</sup> for the two pollutants, including concentration data reported on DMRs.
- Contacted several OCPSF facilities reporting nitrate releases to TRI to gather underlying discharge concentrations that formed the basis for releases reported to TRI as well as information on process operations contributing to those releases and wastewater treatment technologies employed.<sup>20</sup>
- Contacted state permitting authorities to further understand the development of pollutant permit limits and current processes for managing wastewater containing these pollutants.
- Researched the performance of available treatment technologies in the Industrial Wastewater Treatment Technology (IWTT) Database for nitrate.
- Reviewed available data in Canada’s National Pollutant Release Inventory (NPRI) to identify any additional pollutants that may be present in OCPSF wastewater discharges that are not reported in the U.S. under the TRI or DMR programs.

Table 4-22 compares the 2013 and 2014 TRI and DMR TWPE and the number of facilities reporting discharges of the two pollutants. Section 4.2.4 presents EPA’s analyses and results related to total residual chlorine. Section 4.2.5 presents EPA’s analyses and results related to nitrate. Section 4.2.6 presents EPA’s analysis of the NPRI data.

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<sup>19</sup> EPA evaluated 2014 data because it represented the most current and complete DMR and TRI dataset available at the start of the current review. Note that EPA evaluated 2013 DMR and TRI data in support of the 2015 Annual Review.

<sup>20</sup> Chlorine is a TRI listed chemical, however, the reported chlorine constituent is a gaseous form of the chemical, which EPA has concluded does not lead to water releases under normal circumstances. Therefore, EPA excludes water releases of chlorine reported to TRI from the Water Pollutant Loading Tool. The TRI program does not include total residual chlorine in its list of reported chemicals (U.S. EPA, 2014c). As a result, EPA limited its review to total residual chlorine data reported on 2014 DMRs.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-22. 2013 and 2014 DMR and TRI TWPE and Number of OCPSF Facilities Discharging Total Residual Chlorine and Nitrate**

Pollutant	2014 TRI Data		2013 TRI Data		2014 DMR Data		2013 DMR Data	
	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE	Number of Facilities <sup>a</sup>	TWPE
Total Residual Chlorine	NR	NR	NR	NR	102	101,000 <sup>b</sup>	97	49,200
Nitrate	120	14,000	121	13,200	14	337	16	329
<b>Total for All Pollutants Reported</b>	<b>649</b>	<b>379,000<sup>c</sup></b>	<b>651</b>	<b>286,000<sup>d</sup></b>	<b>271</b>	<b>314,000<sup>c</sup></b>	<b>280</b>	<b>224,000<sup>d</sup></b>

Sources: *TRILTOOutput2014\_v1*; *TRILTOOutput2013\_v1*; *DMRLTOOutput2014\_v1*; *DMRLTOOutput2013\_v1*.

Note: Sums of individual values may not equal the total presented, due to rounding.

NR: not reported.

<sup>a</sup> Number of OCPSF facilities with TWPE greater than zero.

<sup>b</sup> The 2014 total residual chlorine DMR TWPE includes corrected data for the top discharging facility carried over from the 2015 Annual Review (U.S. EPA, 2016a).

<sup>c</sup> EPA did not complete a comprehensive quality review of the remainder of the 2014 TRI and DMR data; therefore, this total may include outliers. See Section 2.1 for more information.

<sup>d</sup> Total includes corrected data as identified during the 2015 Annual Review (U.S. EPA, 2016a).

#### **4.2.4 OCPSF Category Review of Total Residual Chlorine Discharges**

As described in Section 4.2.2, from the 2015 Annual Review, EPA identified 97 facilities with total residual chlorine discharges in the 2013 DMR data, and an indication that three of the top four facilities reporting total residual chlorine discharges only have minimum total residual chlorine limits in their permits. Therefore, EPA concluded that further investigation of this pollutant is appropriate to decide whether discharges are industry-wide and present at a level substantial enough for further treatment. Total residual chlorine does not have limitations under the OCPSF ELGs and was not identified as a pollutant of concern during the development of the ELGs. Additionally, EPA has not conducted a detailed review of total residual chlorine discharges as part of recent annual reviews or studies of the industry, outside of the preliminary review conducted as part of the 2015 Annual Review.

For the current review, EPA focused its evaluation on effluent concentrations of total residual chlorine. As shown in Table 4-22, 102 facilities reported releases of total residual chlorine on 2014 DMRs.

To understand the magnitude and potential hazard of the discharges, EPA obtained available average total residual chlorine concentration data for 71 OCPSF facilities from 2014 DMRs, following the methodology outlined in Section 2.1.4. <sup>21</sup> EPA compiled and compared these data to the national recommended aquatic life water quality criteria for receiving water bodies for chlorine (maximum concentration of 19 micrograms per liter (µg/L) and continuous

<sup>21</sup> EPA reviewed total residual chlorine concentration data for OCPSF facilities that report monthly average concentration values in the 2014 DMR data; not all facilities with total residual chlorine loads report monthly average concentration data. Additionally, the concentration data includes facilities with permit limits as well as monitoring requirements for total residual chlorine.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2–Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

concentration of 11 µg/L) (ERG, 2016; U.S. EPA, 2016d). The combination of a maximum concentration and a continuous concentration provide an appropriate degree of protection to aquatic organisms and their uses in receiving waters and protect from acute and chronic toxicity to animals, toxicity to plants, and bioaccumulation by aquatic organisms. The criteria consider factors such as species growth, reproduction, and survival along with quality of the receiving water (hardness, pH, salinity etc.). DMR data reflect facility effluent measurements, typically at the end of the discharge pipe (U.S. EPA, 1985). Therefore, although the comparison of aquatic life water quality criteria to effluent measurements does not determine if water quality criteria in these facilities’ receiving waters are being violated (since flow, dilution, frequency and duration are not possible to evaluate), this comparison does provide a frame of reference for better understanding the magnitude of the total residual chlorine discharges and their potential for posing a hazard.

Table 4-23 compares the minimum, median, and maximum 2014 average total residual chlorine concentration data for OCPSF facilities to the maximum and continuous national recommended aquatic life water quality criteria for chlorine.

**Table 4-23. Comparison of OCPSF Facility 2014 Average Total Residual Chlorine Concentration Data to Water Quality Criteria**

	Number of Data Points <sup>a</sup>	Average Total Residual Chlorine Concentration		
		Minimum (mg/L)	Median (mg/L)	Maximum (mg/L)
2014 OCPSF Facility DMR Data	82	0.00002	0.018	1.23
Maximum Concentration Chlorine Aquatic Life Water Quality Criterion	0.019 mg/L			
Continuous Concentration Chlorine Aquatic Life Water Quality Criterion	0.011 mg/L			

Source: *DMRLTConcOutput2014\_v1*, (U.S. EPA, 2016d).

<sup>a</sup> The number of data points is by outfall, not by facility. Some facilities have more than one outfall.

As shown, the median total residual chlorine concentration from OCPSF facilities falls just below the maximum (acute) concentration aquatic life water quality criterion (0.019 mg/L) for chlorine, but slightly above the continuous (chronic) concentration aquatic life water quality criterion (0.011 mg/L).

To further understand the sources, potential impact, and treatment or control of total residual chlorine discharges, EPA contacted several states that have OCPSF facilities with total residual chlorine permit limits, presented in Section 4.2.4.1.

#### **4.2.4.1 Summary of Permit Reviews and Information Provided by States Regarding Discharges of Total Residual Chlorine**

EPA contacted four state permitting authorities to discuss total residual chlorine discharges: the Iowa Department of Natural Resources (IA DNR), Nebraska Department of Environmental Quality (NE DEQ), West Virginia Department of Environmental Protection (WV DEP), and the Texas Commission on Environmental Quality (TCEQ). EPA’s purpose was to understand how permit limits or other requirements are established, what processes or operations

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

at OCPSF facilities lead to total residual chlorine discharges, and how discharges are treated. Table 4-24 presents the number of OCPSF facilities in each state with 2014 DMR total residual chlorine loads greater than zero. EPA prioritized the four states to contact based on the number of facilities with 2014 DMR total residual chlorine discharges. In selecting these states, EPA also considered the stringency of total residual chlorine permit limits. EPA summarizes its discussions and the information obtained from each state below.

**Table 4-24. OCPSF Facility Total Residual Chlorine 2014 DMR Discharges by State**

State Name	Count of Facilities with Loads Greater than Zero
Iowa	24
Texas	17
Nebraska	10
West Virginia	9
Indiana	8
Illinois	7
Louisiana	5
New York	4
Tennessee	3
South Carolina	3
Connecticut	3
Virginia	3
South Dakota	2
Massachusetts	1
Utah	1
Florida	1
Pennsylvania	1
Total	102

Source: *DMRLOutput2014\_v1*

### ***Iowa***

EPA contacted the IA DNR to discuss permitting practices for total residual chlorine and to obtain the permits for four OCPSF facilities accounting for the majority of 2014 DMR total residual chlorine discharges in Iowa. The state contact also provided information on five additional OCPSF facilities in the state.<sup>22</sup>

Based on a review of the permits for the top discharging facilities and discussions with IA DNR, the state typically calculates total residual chlorine limits using water-quality-based effluent limits (WQBELs) and Wasteload Allocations (WLA). IA DNR develops a WLA for each facility that may discharge treated or untreated wastewater into state waters to assure that the permitted effluent limits meet applicable state water quality standards. IA DNR defines a WLA as the portion of a receiving water’s total assimilative capacity that is allocated to one of its existing or future point sources of pollution. IA DNR bases the calculation of the WLA on conservative assumptions to protect water quality under worst-case scenarios. Total residual chlorine WLAs are typically calculated using mass balance calculations, taking into account mixing zones and decay within pipes or in holding tanks (Hieb, 2016). IA DNR uses the total

<sup>22</sup> Two of the five facilities for which the state provided information do not have total residual chlorine limits. EPA did not include these facilities in this review.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

---

residual chlorine WLA calculated for a facility discharge and information on the source of total residual chlorine at the facility (use chlorine to treat municipal water, addition of chlorine in its processes or wastewater treatment, etc.) before deciding to add a total residual chlorine permit limit.

From review of facility permits, waste streams associated with total residual chlorine limits contain cooling water, boiler blowdown, and/or reverse osmosis (RO) reject (or a concentrated stream). Additionally, facilities may be adding chlorine to the wastewater treatment process in the form of sodium hypochlorite to control biological growth. The state contact stated that facilities may use a chemical feed of sodium bisulfate to help treat total residual chlorine (Hieb, 2016). Table 4-26 below provides a summary of the permit information for the seven facilities identified.

### ***Nebraska***

EPA contacted the NE DEQ to discuss permitting practices for total residual chlorine and to obtain permits for four OCPSF facilities accounting for the majority of 2014 DMR total residual chlorine discharges in Nebraska. According to the state contact the state uses WQBELs to calculate water quality limits for individual facilities. These calculations consider mixing zones. The state focuses on limits for total residual chlorine but will sometimes look at total available chlorine limits for internal outfalls only (Anderson, 2016).

Most of the OCPSF facilities in Nebraska are ethanol plants that may have total residual chlorine limits due to cooling tower blowdown where chlorine is used as a biocide. According to the state contact, the facilities typically treat the chlorine with a sodium bisulfite dechlorination system (Anderson, 2016). From review of facility permits, waste streams associated with total residual chlorine limits contain cooling water, boiler blowdown, and/or RO reject (or a concentrated stream). Table 4-26 below provides a summary of the permit information for the four facilities identified.

### ***West Virginia***

EPA contacted WV DEP to discuss permitting practices for total residual chlorine and to obtain permits for four OCPSF facilities accounting for the majority of 2014 DMR total residual chlorine discharges in West Virginia. If the facility reports total residual chlorine discharges in the data submitted with their permit application, the state uses the WQBELs along with facility-specific information to determine a permit limit. The state also considers mixing zones and dilution factors when determining a permit limit. The state contact said that total residual chlorine limits are more commonly seen for OCPSF facilities compared to other industries because dechlorination systems are common (Lockhart, 2016). Table 4-26 below provides a summary of the permit information for the four facilities identified.

### ***Texas***

In reviewing 2014 DMR data for total residual chlorine, EPA identified several facilities in Texas that reported minimum total residual chlorine concentrations on their DMRs instead of,

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

or in addition to, either average or maximum concentrations.<sup>23</sup> As outlined in Section 2.1.4, EPA obtained facility minimum total residual chlorine effluent concentrations from DMRs for each outfall, by reporting period (e.g., monthly, quarterly). EPA averaged the concentrations for each reporting period to calculate an annual average of the minimum total residual chlorine concentrations reported per outfall. Table 4-25 presents the minimum, median, and maximum of the 2014 averaged minimum total residual chlorine concentrations reported by OCPSF facilities with minimum permit limits. All facilities with minimum permit limits are all located in Texas.

**Table 4-25. Summary of OCPSF Facility Minimum Total Residual Chlorine 2014 Concentration Data**

	Number of Data Points <sup>a</sup>	Minimum Total Residual Chlorine Concentration		
		Minimum (mg/L)	Median (mg/L)	Maximum (mg/L)
OCPSF Facility DMR Data	17	0.54	1.94	192.7

Source: *DMRLTConcOutput2014\_v1*

<sup>a</sup> The number of data points is by outfall, not by facility. Some facilities have more than one outfall.

EPA contacted TCEQ to understand the circumstances under which a facility would report a minimum total residual chlorine concentration, to discuss permitting practices for total residual chlorine, and to obtain permits for the five OCPSF facilities accounting for the majority of 2014 DMR total residual chlorine discharges in Texas. From its review of the 2014 DMR data, EPA identified that four of the five OCPSF facilities with the highest total residual chlorine discharges in Texas have minimum total residual chlorine permit limits, as opposed to average or maximum limits.

The state contact stated that the minimum limits for total residual chlorine are applied in a draft permit when the discharge from an OCPSF facility contains sanitary wastewater or demonstrates a reasonable potential for process-based bacteria to be discharged. In these instances, the TCEQ follows the guidelines of 30 TAC §309.3(g)(2)<sup>24</sup> when applying total residual chlorine limits in a discharge permit for an OCPSF facility (Gibson, 2016).

The Texas Administrative Code 309.3(g)(2) establishes requirements for disinfection of facility effluent and states: “Where chlorination is utilized, any combination of detention time and chlorine residual where the product of chlorine (Cl<sub>2</sub> mg/l) X Time (T minutes) equals or exceeds 20 is satisfactory provided that the minimum detention time is at least 20 minutes and the minimum residual is at least 0.5 mg/L. The maximum chlorine residual in any discharge shall in no event be greater than four mg/l per grab sample, or that necessary to protect aquatic life.”

The state contact indicated that it is very common for industrial facilities, including OCPSF facilities, to treat sanitary wastewater onsite, rather than route it to a POTW. Table 4-26 below provides a summary of the permit information for the five Texas facilities identified. All

<sup>23</sup> Facilities may submit minimum, average, and/or maximum concentration measurements on their DMRs, depending on the type of limits in a permit, per reporting period (e.g., monthly, quarterly).

<sup>24</sup> Available in the [Texas Administrative Code](#).

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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permits reviewed for OCPSF facilities in Texas indicate that the facilities are mixing sanitary wastewater with process wastewater.

***Summary of Permit Reviews for Total Residual Chlorine***

EPA reviewed 20 OCPSF facility permits, in total, across four states. Table 4-26 summarizes the information obtained from these permit reviews. As shown in the table, seven of the 20 facilities with total residual chlorine permit limits and/or monitoring requirements are involved in corn milling and/or ethanol production.

From discussions with states and review of facility permits, EPA concluded that Iowa, Nebraska, and West Virginia calculate total residual chlorine permit limits based on WQBELs, that consider mixing zones and dilution factors. EPA also concluded that total residual chlorine discharges do not likely result from OCPSF process wastewater; a majority of the waste streams with associated total residual chlorine limits across all of the states include cooling water, boiler blowdown, and/or RO reject (or concentrated stream), which may be commingled with process wastewater. In many instances, facilities may be adding chlorine to waste streams that are not considered process waste streams to control undesirable biological growth. As shown in Iowa and Nebraska, industrial facilities may have process controls in place to address total residual chlorine discharges, such as dechlorination systems.

In addition, total residual chlorine discharges may result from OCPSF facilities treating sanitary wastewater, which is commingled with process wastewater. Two West Virginia facility permits indicate that facilities in this state can commingle sanitary wastewater with process wastewater; however, the associated outfalls have daily maximum and monthly average permit limits for total residual chlorine. The state of Texas also allows OCPSF facilities to commingle sanitary wastewater with process wastewater. In these instances, the state will establish minimum total residual chlorine permit limits for the purpose of disinfection of the effluent.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average TRC Limit	Daily Maximum TRC Limit	Outfall Waste-streams	Notes
IA0081043	Southwest Iowa Renewable Energy	Council Bluffs, IA	2869: Industrial Organic Chemicals NEC	Fuel grade ethanol production from corn, using the dry-mill process.	001	2.233 mg/L, 6.163 lb/day	2.233 mg/L, 6.163 lb/day	Noncontact cooling water, softener regeneration, RO reject, and sand filter backwash (no process water is discharged).	Facility chlorinates after clarification and dechlorinates prior to reverse osmosis.
IA0082279	ADM Bioprocessing <sup>a</sup>	Clinton, IA	2079: Edible Fats & Oils; 2899: Chemical Preparations NEC	Biological fermentation using dextrose feedstock.	001	1.067 mg/L, 3.363 lb/day	1.067 mg/L, 3.363 lb/day	Noncontact cooling water blowdown (no process water is discharged).	Facility uses municipal water for cooling and adds sodium hypochlorite to the cooling tower water.
IA0079456	The Andersons Denison Ethanol <sup>b</sup>	Denison, IA	2869: Industrial Organic Chemicals NEC	Ethanol production facility using the dry-mill process.	001	0.355 mg/L, 0.451 lb/day	0.355 mg/L, 0.451 lb/day	Noncontact cooling water, softener regeneration, RO reject, and sand filter backwash (no process water is discharged).	Facility adds sodium hypochlorite to control biological growth. Dechlorination provided by sodium bisulfite.
IA0081248	Plymouth Energy LLC	Merrill, IA	2869: Industrial Organic Chemicals NEC	Ethanol production facility using the dry-mill process.	001	0.311 mg/L, 0.834 lb/day	0.319 mg/L, 0.856 lb/day	Cooling tower blowdown, boiler blowdown, RO reject, water softener regeneration and filter backwash.	Facility chlorinates and dechlorinates.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average TRC Limit	Daily Maximum TRC Limit	Outfall Waste-streams	Notes
IA0000205	Monsanto Company <sup>c</sup>	Muscatine, IA	2869: Industrial Organic Chemicals	Organic chemical and plastics material & resin manufacturing.	001	0.663 mg/L, 26.462 lb/day	0.663 mg/L, 26.462 lb/day	Total plant discharge to the Mississippi River.	No additional information on total residual chlorine discharges provided.
IA0000256	Roquette America, Inc. <sup>c</sup>	Keokuk, IA	2046: Wet Corn Milling	Not provided.	001	0.393 mg/L, 0.638 lb/day	0.393 mg/L, 0.638 lb/day	Boiler blowdown.	Load limits effective 11/09/12 to 11/08/17. Concentration limits effective 01/01/15 to 11/08/17.
					009	0.393 mg/L, 103 lb/day	0.393 mg/L, 103 lb/day	RO reject, boiler blowdown, cooling tower blowdown, etc.	Load and concentration limits effective 1/1/15 to 11/8/17.
					011	0.393 mg/L, 17 lb/day	0.393 mg/L, 17 lb/day	Cooling tower blowdown, surface runoff, heat exchanger drain drainage, etc.	
					012	0393 mg/L, 14 lb/day	0393 mg/L, 14 lb/day	Wastewater from corn wet milling operations.	

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2–Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

<b>NPDES ID</b>	<b>Facility Name</b>	<b>Facility Location</b>	<b>SIC Code</b>	<b>Description</b>	<b>Outfall</b>	<b>Monthly Average TRC Limit</b>	<b>Daily Maximum TRC Limit</b>	<b>Outfall Waste-streams</b>	<b>Notes</b>
IA0052535	New Haven Chemicals Iowa, LLC.	Manly, IA	2865: Cyclic Organic Crudes; 2869: Industrial Organic Chemicals NEC	Sodium methylate manufacturing.	003	0.274 mg/L, 0.180 lb/day	0.332 mg/L, 0.219 lb/day	Treated process wastewater, laboratory wastewater, contaminated tank farm runoff, boiler blowdown, cooling tower blowdown, RO reject, & filter backwash.	Facility is a new discharger as of January 2016. The facility is using bleach as a cooling tower additive, therefore, a TRC limit was included in the permit.
NE0131334	Cargill Corn Milling <sup>d</sup>	Blair, NE	2046: Wet Corn Milling; 2869: Industrial Organic Chemicals; 2821: Plastics Materials & Resins	Corn milling & ethanol production.	001	Monitoring only	Monitoring only	Discharge from Cargill’s privately owned WWTP.	The WWTP treats process and non-process wastewater from corn milling and ethanol production facilities as well as process wastewater from other plants within the complex. Includes noncontact cooling tower blowdown.
					002	0.011 mg/L, 0.014 kg/d	0.019 mg/L, 0.027 kg/d	Noncontact cooling tower blowdown.	Cooling tower blowdown from the Cargill corn milling facility.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average TRC Limit	Daily Maximum TRC Limit	Outfall Waste-streams	Notes
					003	0.011 mg/L, 0.002 kg/d	0.019 mg/L, 0.004 kg/d	Noncontact cooling water blowdown.	Cooling tower blowdown from the Germ facility (another facility onsite).
NE0134279	Cornhusker Energy Lexington, LLC. <sup>e</sup>	Lexington, NE	2869: Industrial Organic Chemicals	Fuel-grade ethanol production.	001	3/1-5/31: 0.01 mg/L, 0.02 kg/d	3/1-5/31: 0.02 mg/L, 0.03 kg/d	Noncontact cooling water.	Facility has seasonal daily maximum total residual chlorine limits. <sup>f</sup>
							6/1-10/31: 0.02 mg/L, 0.04 kg/d		
							11/1-2/28: 0.02 mg/L, 0.03 kg/d		
NE0137715	Green Plains Wood River	Wood River, NE	2869: Industrial Organic Chemicals	Fuel-grade ethanol production.	001	0.010 mg/L	0.020 mg/L	Non-process wastewater including cooling tower blowdown, RO reject, filter backwash, etc.	No additional information on total residual chlorine discharges provided.
NE0138045	Bridgeport Ethanol LLC.	Bridgeport, NE	2869: Industrial Organic Chemicals	Dry grain milling ethanol plant.	001	3/1-5/31: 0.18 mg/L, 0.11 kg/d	3/1-5/31: 0.37 mg/L, 0.22 kg/d	Non-process wastewater including cooling water and utility wastewaters.	Facility has seasonal total residual chlorine limits. <sup>f</sup>
						6/1-10/31: 0.14 mg/L, 0.08 kg/d	6/1-10/31: 0.28 mg/L, 0.16 kg/d		
						11/1-2/28: 0.73 mg/L, 0.42 kg/d	11/1-2/28: 1.46 mg/L, 0.85 kg/d		

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2–Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average TRC Limit	Daily Maximum TRC Limit	Outfall Waste-streams	Notes
WV0005169	Bayer Material Science	New Martinsville, WV	2821: Plastics Materials, 2865: Cyclic Organic Crudes, 2869: Industrial Organic Chemicals;	Plastics & Organic Chemical Manufacturing	001	294 µg/L	589 µg/L	Cooling water, stormwater runoff, process water, other.	No additional information on total residual chlorine discharges provided.
WV0000787	Cytec Industries Inc.	Belmont, WV	2869: Industrial Organic Chemicals; 2899: Chemical Preparations	Organic Chemical Manufacturing	001	11/1/15-10/31/17: Monitoring only	11/1/15-10/31/17: Monitoring only	Cooling water, stormwater runoff, process water, other.	Interim limits <sup>g</sup>
					001	11/1/17 – 6/30/19: 28 µg/L	11/1/17 – 6/30/19: 57 µg/L		Final limits
					008	11/1/17 – 6/30/19: 6.1 µg/L	11/1/17 – 6/30/19: 9.7 µg/L	Sanitary wastewater, cooling water, stormwater runoff.	Final limits
WV0000841	Sabic Innovative Plastics US LLC.	Washington, WV	2822: Synthetic Rubber; 2821: Plastics Materials	Manufacturing of ABS (acrylonitrile, butadiene, styrene) polymers.	001	28 µg/L	57 µg/L	Sanitary wastewater, stormwater runoff, process water, other.	Facility wastewater treatment includes neutralization system, primary clarification, rotary screen, flow equalization.
					002	Monitoring only	Monitoring only	Cooling water, stormwater runoff, other.	

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

<b>NPDES ID</b>	<b>Facility Name</b>	<b>Facility Location</b>	<b>SIC Code</b>	<b>Description</b>	<b>Outfall</b>	<b>Monthly Average TRC Limit</b>	<b>Daily Maximum TRC Limit</b>	<b>Outfall Waste-streams</b>	<b>Notes</b>
					006	Monitoring only	Monitoring only	Cooling water, stormwater runoff, other.	aeration, secondary clarification, disinfection, and tertiary filters.
WV0116416	Kureha PGA, LLC	Belle, WV	Not provided.	Not provided.	001	Monitoring only <sup>h</sup>	Monitoring only <sup>h</sup>	Cooling water, stormwater runoff.	No additional information on total residual chlorine discharges provided.
TX0006017	Oxea Bay City Plant	Bay City, TX	2869: Industrial Organic Chemicals	Organic chemical manufacturing.	001	1.0 mg/L (minimum limit after a detention time of at least 20 minutes) <sup>i</sup>		Treated sanitary wastewater, process wastewater, stormwater, groundwater from monitoring wells.	No additional information on total residual chlorine discharges provided.
TX0003531	Equistar Chemicals Channelview Complex	Houston, TX	2869: Industrial Organic Chemicals	Synthetic organic chemical manufacturing.	001	1.0 mg/L (minimum limit after a detention time of at least 20 minutes) <sup>i</sup>		Treated process wastewater, auto shop wastewater, laboratory wastewater, sanitary wastewater, cooling tower blowdown.	No additional information on total residual chlorine discharges provided.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average TRC Limit	Daily Maximum TRC Limit	Outfall Waste-streams	Notes
TX0005061	Goodyear Tire & Rubber Co.	Beaumont, TX	2821: Plastics Materials, 2822: Synthetic Rubber, 2869: Industrial Organic Chemicals	Synthetic rubber, adhesive resins, antioxidants & isoprene manufacturing.	001	1.0 mg/L (minimum limit after a detention time of at least 20 minutes) <sup>i</sup>		Treated process wastewater, utility wastewater, sanitary wastewater, process area stormwater.	No additional information on total residual chlorine discharges provided.
TX0006084	Rohmax USA	Deer Park, TX	2869: Industrial Organic Chemicals; 2819: Industrial Inorganic Chemicals, NEC	Chemical manufacturing facility.	001	Monitoring only	Monitoring only	Treated process wastewater, stormwater, utility wastewater, sanitary wastewater.	No additional information on total residual chlorine discharges provided.
					009	Monitoring only	Monitoring only		
					010	21.4 lb/day	36.0 lb/day	Reporting outfall created for the purpose of regulating the sum of pollutant discharges via 001-009.	

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-26. Summary of Permit Information for OCPSF Facilities Discharging Total Residual Chlorine**

<b>NPDES ID</b>	<b>Facility Name</b>	<b>Facility Location</b>	<b>SIC Code</b>	<b>Description</b>	<b>Outfall</b>	<b>Monthly Average TRC Limit</b>	<b>Daily Maximum TRC Limit</b>	<b>Outfall Waste-streams</b>	<b>Notes</b>
TX0077577	Ineos Nitriles USA LLC. Green Lake Plant	Port Lavaca, TX	2869: Industrial Organic Chemicals; 2819: Industrial Inorganic Chemicals, NEC	Chemical plant manufacturing acrylonitrile, acetone cyanohydrin, acetonitrile, & catalyst.	001	1.0 mg/L (minimum limit after a detention time of at least 20 minutes) <sup>i</sup>		Demineralizer regenerant, boiler blowdown, cooling tower blowdown, RO reject, treated sanitary wastewater, supernatant from lime sludge pits.	No additional information on total residual chlorine discharges provided.

Source: (IA DNR, 2011, 2012a, 2012b, 2012c, 2013, 2014, 2016; NE DEQ, 2011, 2012, 2014, 2015; TCEQ, 2007, 2009, 2015, 2016a, 2016b; WV DEP, 2013a, 2013b, 2015a, 2015b)

TRC: total residual chlorine

<sup>a</sup> Formerly ADM Polymers.

<sup>b</sup> Formerly Amazing Energy LLC.

<sup>c</sup> No permit fact sheet available for this facility, limited background information provided in the facility permit.

<sup>d</sup> From the facility permit, Cargill Corn Milling is a large complex with multiple manufacturing facilities onsite. The complex has a privately owned wastewater treatment plant which treats process and non-process wastewater from the whole complex.

<sup>e</sup> The facility changed ownership in May 2016, it is now owned by Chief Ethanol Fuels, Inc.

<sup>f</sup> Seasonal TRC limits are included in the permit to ensure the effluent discharge does not exceed the acute and chronic instream water quality criteria.

<sup>g</sup> Facility has interim permit limits due to construction activities on site.

<sup>h</sup> Facility has monitoring only requirements until November 2017, then the permit limits become 0.08 mg/L (monthly average) & 0.16 mg/L (daily maximum).

<sup>i</sup> Facility has minimum total residual chlorine limit.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

#### 4.2.5 OCPSF Category Review of Nitrate Discharges

As described in Section 4.2.2, from the 2015 Annual Review, EPA identified 121 facilities with nitrate releases in the TRI data and concluded that further investigation of nitrate is appropriate to evaluate whether discharges are industry-wide and present at a level substantial enough for further treatment. Nitrate does not have limitations under the OCPSF ELGs and was not identified as a pollutant of concern during the development of the ELGs. Additionally, EPA has not conducted a detailed review of nitrate discharges as part of recent annual reviews or studies of the industry, outside of the preliminary review conducted as part of the 2015 Annual Review.

In the absence of a comparison point directly relevant to the OCPSF category, EPA compared the effluent nitrate concentration data to a baseline value for nitrate from the *Development Document for the Effluent Limitations Guidelines and Standards for the Centralized Waste Treatment Industry – Final* (CWT Development Document) (U.S. EPA, 2000). In general, the baseline value is equal to the nominal quantitation limit identified for the method (in the case of nitrate, EPA Method 1620). EPA also compared the concentration data to ten times the baseline value for nitrate from the CWT Development Document. EPA performed these comparisons to provide a frame of reference for the magnitude of the nitrate discharges and to generally assess whether the concentrations are at a level substantial enough for further treatment (in this case, ten times the baseline value for nitrate identified in the CWT Development Document is considered substantial enough for treatment).

In addition, EPA compared the concentration data for direct dischargers to the national primary drinking water regulation for nitrate. The national primary drinking water regulations apply to public water systems and protect drinking water quality by limiting the levels of contaminants that can adversely affect public health through setting maximum contaminant levels (MCLs). The drinking water regulations consider mixing zones and downstream mixing, while the DMR and TRI data result from facility effluent measurements, typically at the end of the discharge pipe. Therefore, this comparison merely provides a frame of reference for better understanding the magnitude of the nitrate discharges and their potential for posing a hazard. Table 4-27 presents the baseline comparison values and national primary drinking water regulation for nitrate.

**Table 4-27. Baseline Values and Water Quality Criteria for Nitrate**

<b>Baseline Value for Nitrate (mg/L)<sup>a</sup></b>	<b>10x Baseline Value for Nitrate (mg/L)</b>	<b>National Primary Drinking Water Regulation for Nitrate (mg/L)</b>
0.05	0.5	10

Source: (U.S. EPA, 2000) (for the baseline values); (U.S. EPA, 2016e) (for the National Primary Drinking Water Regulations for nitrate).

Note: The baseline values and the National Primary Drinking Water Regulation for nitrate are reported as nitrate as nitrogen (NO<sub>3</sub>-N).

<sup>a</sup> The baseline value is equal to the nominal quantitation limit identified for EPA Method 1620.

For the current review, EPA focused its evaluation on effluent concentrations of nitrate. As shown in Table 4-22, 120 facilities reported releases of nitrate to TRI in 2014 (includes both direct and indirect releases), while only 14 facilities reported nitrate discharges on 2014 DMRs.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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Following the methodology outlined in Section 2.1.4, EPA obtained concentration data for 13 of the facilities reporting nitrate on DMRs in 2014.<sup>25</sup> Additionally, EPA identified and contacted eight facilities that reported direct and indirect releases of nitrate to TRI in 2014 to gather the underlying nitrate concentration data that formed the basis for the TRI-reported releases and identify sources of nitrate in wastewater. EPA compiled the DMR and TRI concentration data supporting this review (ERG, 2016). Table 4-28 presents the facilities EPA contacted along with information the facilities provided. All eight facilities listed in Table 4-28 provided underlying concentration data used to calculate nitrate releases reported to TRI. EPA presents its analysis of direct and indirect discharges of nitrate and comparison to baseline values and water quality criteria in Sections 4.2.5.1 and 4.2.5.2.

To further understand discharges and treatment of nitrate, EPA contacted select states that have a high proportion of OCPSF facilities with reported nitrate discharges. EPA also evaluated available treatment technology pollutant removal data. These analyses are presented in Sections 4.2.5.3 and 4.2.5.4, respectively.

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<sup>25</sup> Only 13 OCPSF facilities have average nitrate concentration data out of a total of 14 OCPSF facilities with nitrate discharges greater than zero in the 2014 DMR data.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-28. Facilities Contacted to Obtain Underlying Concentration Data for Nitrate Releases Reported to TRI in 2014**

Facility Name	Facility Location	Direct/Indirect Discharger	Facility Process & Treatment Technology Information	Concentration Data Provided <sup>a</sup>	Reference
DSM Chemicals	Augusta, GA	Direct	Facility produces caprolactam, a monomer used to make nylon 6 (for use in nylon fibers). Oxidation of organic raw materials during processing forms ammonia and nitrites. These compounds are then oxidized in the wastewater treatment plant to form nitrate.	Yes	(Connell, 2016)
Eastman Chemical Co. Tennessee	Kingsport, TN	Direct	No additional information provided.	Yes	(Smith, 2016)
Ascend Performance Materials Operations LLC – Decatur Plant	Decatur, AL	Direct	Nitrate discharges result from the facility’s wastewater treatment plant.	Yes	(Burke, 2016)
BASF Corporation	Geismar, LA	Direct	Complex has many facilities on site, one of which manufactures dinitrotoluene (DNT). This process can lead to high levels of nitrate in process wastewater. BASF has incorporated anoxic zones in their treatment system to allow removal of nitrate and has seen removal rates of up to 99 percent in certain conditions.	Yes	(Hillman, 2016)
Invista Camden Plant	Lugoff, SC	Direct	Nitrate may be generated by the nitrification of organic nitrogen-containing compounds in the facility’s aerobic biological wastewater treatment plant. The organic nitrogen-containing compounds result from wet scrubbers that capture vapor by-products from the production of nylon.	Yes	(Twait, 2016)
Honeywell International Inc. Hopewell Plant	Hopewell, VA	Both	No specific treatment for nitrate at the facility.	Yes	(Parker, 2016)
Eastman Chemical Resins Inc.	West Elizabeth, PA	Both	No additional information provided.	Yes	(Petrosky, 2016)
First Chemical Corp.	Pascagoula, MS	Indirect	No additional information provided.	Yes	(Field, 2016)

<sup>a</sup> EPA compiled the concentration data provided by the facilities into a spreadsheet to support the analyses discussed in this section (ERG, 2016).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

#### 4.2.5.1 Evaluation of Direct Discharge Nitrate Concentrations

EPA obtained and compared the 2014 nitrate concentration data for direct discharging OCPSF facilities to the baseline value, 10 times the baseline value, and the national primary drinking water regulation for nitrate, as identified in Table 4-27 (0.05 mg/L, 0.5 mg/L, and 10 mg/L, respectively). Table 4-29 presents a summary of the average OCPSF direct discharging facility nitrate DMR and TRI concentration data as well as these comparison values. As shown, the median concentrations for the TRI data and the DMR data fall an order of magnitude above 10 times the baseline value (0.5 mg/L). Both TRI and DMR median concentrations fall below the national primary drinking water regulation (10 mg/L). Approximately one third of the nitrate concentrations in both DMR and TRI data fall above the national primary drinking water regulation. These data suggest that nitrate may be present at a level significant enough for further treatment, but generally below concentrations deemed unacceptable for drinking water.

**Table 4-29. Comparison of OCPSF Facility 2014 Average Direct Discharge Nitrate Concentration Data to Baseline Values and Drinking Water Standards**

Data Type	Number of Data Points <sup>a</sup>	Average Nitrate Concentrations (mg/L)		
		Minimum	Median	Maximum
2014 OCPSF Facility TRI Data	12	0.01	2.41	141 <sup>b</sup>
2014 OCPSF Facility DMR Data	14	0.09	2.90	68
<b>Baseline Value</b>	<b>0.05 mg/L</b>			
<b>10x Baseline Value</b>	<b>0.5 mg/L</b>			
<b>National Primary Drinking Water Regulations for Nitrate (MCL)</b>	<b>10 mg/L</b>			

Source: (ERG, 2016; U.S. EPA, 2000, 2016e).

<sup>a</sup> The number of data points represents the number of outfalls, not facilities. Some facilities have more than one outfall.

<sup>b</sup> The maximum concentration is likely an outlier. It is an order of magnitude, or more, higher than the nitrate concentrations reported by other direct discharging facilities.

#### 4.2.5.2 Evaluation of Indirect Discharge Nitrate Concentrations

Only twelve OCPSF facilities (of the 120 that reported releases of nitrate to TRI in 2014) reported indirect releases of nitrate to TRI. EPA contacted three facilities and obtained the underlying concentration data that formed the basis for their reports of indirect nitrate releases to TRI. EPA compared these nitrate concentration data to the baseline value and 10 times the baseline value for nitrate, shown in Table 4-27 (0.05 mg/L and 0.5 mg/L, respectively). Table 4-30 presents the average indirect discharging facility nitrate concentration for each of the three facilities. As shown, all three facilities’ average nitrate concentrations are orders of magnitude higher than the baseline value and 10 times the baseline value. However, because of EPA’s facility selection method, these data represent concentrations from facilities reporting the highest indirect releases of nitrate to TRI.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-30. Comparison of OCPSF Facility 2014 Average Indirect Discharge Nitrate Concentration Data to Baseline Values**

<b>Facility Name and Location</b>	<b>Average Nitrate Concentration</b>
Honeywell International, Hopewell, VA	4.80 mg/L
Eastman Chemical, West Elizabeth, PA	199 mg/L
First Chemical Corp, Pascagoula, MS	77.7 mg/L
<b>Baseline Value</b>	<b>0.05 mg/L</b>
<b>10x Baseline Value</b>	<b>0.5 mg/L</b>

Source: (ERG, 2016; U.S. EPA, 2000)

#### **4.2.5.3 Summary of Permit Reviews and Information Provided by States Regarding Discharges of Nitrate**

As part of this review, EPA contacted WV DEP because West Virginia had the highest percentage of OCPSF facilities with nitrate discharges in DMR (five out of fourteen total). EPA’s purpose was to collect additional information on the development of permit limits to further inform EPA’s understanding of the nitrate discharges.

The WV DEP contact stated that if a facility reports nitrate discharges with their permit application, the state calculates the reasonable potential for discharge to violate water quality standards. The state uses the water quality standards along with facility-specific information to determine a permit limit. The state contact stated that nitrate limits are usually seen in permits from OCPSF facilities only if the facility manufactures organic chemicals containing nitrogen, as these facilities typically discharge nitrate at levels requiring further treatment (Lockhart, 2016). The state contact provided facility permits and fact sheets for the three OCPSF facilities with the largest nitrate discharges in the 2014 DMR data. Table 4-31 presents a summary of the permit information for these three OCPSF facilities, including nitrate permit limits or monitoring requirements. Only one of the facilities has permit limits for nitrate.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2–Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-31. Summary of Permit Information for Three West Virginia OCPSF Facilities**

NPDES ID	Facility Name	Facility Location	SIC Code	Description	Outfall	Monthly Average Nitrate Limit	Daily Maximum Nitrate Limit	Outfall Waste Streams	Notes
WV0000787	Cytec Industries Inc.	Belmont, WV	2869: Industrial Organic Chemicals; 2899: Chemical Preparations	Organic Chemical Manufacturing.	001	11/1/15–10/31/17: Monitoring only	11/1/15–10/31/17: Monitoring only	Treated process wastewater, cooling water, treated ground water, and stormwater runoff.	Interim limits <sup>a</sup>
					001	11/1/17 – 6/30/19: Monitoring only	11/1/17 – 6/30/19: Monitoring only		Final limits
WV0000841	Sabic Innovative Plastics US LLC	Washington, WV	2822: Synthetic Rubber; 2821: Plastics Materials, Synthetic Resins	Manufacturing of ABS (acrylonitrile, butadiene, styrene) polymers.	001	93 mg/L	155 mg/L	Sanitary wastewater, stormwater runoff, process water, other.	None.
WV0116416	Kureha PGA, LLC	Belle, WV	Not provided.	Not provided.	001	Monitoring only	Monitoring only	Cooling water, stormwater runoff.	None.

Source: (WV DEP, 2013, 2015)

<sup>a</sup> Facility has interim permit limits due to construction activities on site.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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#### **4.2.5.4 Evaluation of Available Treatment Technology Performance Data for Nitrate**

EPA reviewed recent literature compiled in the IWTT Database to identify emerging treatment technologies that are being evaluated and/or implemented within the OCPSF industry, or that are being evaluated and/or implemented in other industries, specifically for the removal of nitrate (for more information on the IWTT Database, see Section 6.2 of this report).

EPA queried the IWTT Database for treatment of OCPSF wastewater, which produced no articles with pollutant removal data. EPA then queried IWTT for performance data on the treatment of nitrate in general. Table 4-32 summarizes these systems and their treatment effectiveness. All but two are pilot scale. The systems described in Table 4-32 may not specifically target nitrate removal; however, they do remove high percentages of nitrate. The studies do not show consistent nitrate effluent concentrations, are mostly pilot scale, and are not specific to the OCPSF industry. In addition, the studies also evaluated process wastewater that likely was not commingled and potentially diluted by other non-process waste streams, as may be the case for the DMR nitrate data discussed above. Despite these caveats, the nitrate effluent concentrations are generally similar to or lower than the 2014 DMR OCPSF facility median nitrate concentrations discussed above.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2–Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-32. Summary of Wastewater Treatment Technologies for Nitrate**

Parameter	Wastewater Treatment Technology (Order of Unit Processes)	Effluent Concentration (mg/L)	Percent Removal	Industry	Treatment Scale	Reference
Nitrate	Adsorptive Media	2	50.0%	Petroleum Refining	Full	(Hayes & Sherwood, 2012)
	Membrane Filtration, Ion Exchange, and Reverse Osmosis	2.8	88.8%		Pilot	(Ginzburg & Cansino, 2009)
	Aerobic Fixed Film Biological Treatment	NR	< 100%	Coal Mining	Full	(Reinsel, 2010)
	Flow Equalization, Membrane Filtration, and Reverse Osmosis	0.42	97.5%	Ferroalloy Manufacturing	Pilot	(Benito & Ruiz, 2002)
Nitrate (as N)	Anaerobic Fixed Film Biological Treatment and Membrane Filtration	0.01	99.9%	Coal Mining	Pilot	(Munirathinam, et al., 2011)
	Anaerobic Fixed Film Biological Treatment and Moving Bed Bioreactor	0.7	97.7%		Pilot	(Gay, et al., 2012)
	Ozonation	1.8	10.0%	Textile Mills	Pilot	(Somensi, et al., 2010)
	Granular-Media Filtration, Membrane Filtration, and Reverse Osmosis	0.73	51.3%	Electrical and Electronic Components	Pilot	(Huang, et al., 2011)

NR – Not Reported.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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#### **4.2.6 OCPSF Category NPRI Analysis**

EPA evaluated the utility of using data from Canada’s NPRI to identify potential additional pollutants that may be present in industrial wastewater discharges from facilities in the U.S., as indicated by their presence in industrial wastewater discharges from facilities in Canada. Section 2.2 of this report provides a general overview of the NPRI analysis and methodology. This section presents EPA’s review of the NPRI data specific to the OCPSF Category.

##### **4.2.6.1 NPRI Analysis Overview**

EPA compared water release data in TRI to data reported in Canada’s NPRI for the OCPSF Category to identify pollutants reported in NPRI, but not captured in the TRI. For those pollutants, EPA compared the reporting requirements between NPRI and TRI to understand the impact of any reporting differences (e.g., are the thresholds for reporting similar, do groups of reported chemicals include the same set of individual compounds, etc.) and further evaluated the potential for releases of these pollutants in the U.S.

For this analysis, EPA evaluated 2013 TRI and NPRI data, the most recent data available for both datasets at the time of review. EPA processed the data as described in Section 2.2 to obtain the relevant industry category, pollutant names, facility counts, and water releases for each of the datasets. For facilities associated with the OCPSF Category, EPA compared the list of pollutants with water releases reported to NPRI and TRI.

In 2013, 43 Canadian OCPSF facilities reported water release data for 42 pollutants to NPRI, while 644 U.S. OCPSF facilities reported water release data for 156 pollutants to TRI. As shown in Table 4-33, EPA identified nine pollutants reported to NPRI that were not reported to TRI by OCPSF facilities in 2013. Five of the nine pollutants are not included on the EPCRA Section 313 Chemical List for Reporting Year 2013 (2013 List of TRI Chemicals), therefore, facilities are not required to report releases of these pollutants (U.S. EPA, 2014b).

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-33. Pollutants Reported by OCPSF Facilities to 2013 NPRI but not to 2013 TRI**

Pollutant Name	On 2013 List of TRI Chemicals <sup>a</sup>	Number of NPRI OCPSF Facilities Reporting Pollutant Release to Water	Percentage of all NPRI OCPSF Facilities Reporting Water Release
2-Butoxyethanol	N	2	5%
Chlorine	Y <sup>b</sup>	1	2%
HCFC-123 and all isomers	Y	1	2%
HCFC-124 and all isomers	Y	1	2%
Isopropyl alcohol	Y	4	9%
Nonylphenol and its ethoxylates	N	2	5%
Octylphenol and its ethoxylates	N	2	5%
Phosphorus (total)	N <sup>c</sup>	10	23%
Sodium fluoride	N	1	2%

Source: *NPRICompare2013, TRILTOOutput2013\_v1*, (U.S. EPA, 2014b)

HCFC: Hydrochlorofluorocarbons

a Refers to pollutants included in the 2013 List of TRI Chemicals, regardless of whether water releases were reported for the pollutant.

b Chlorine is in gaseous form, and not expected to be released to water under typical conditions (U.S. EPA, 1998).

c The 2013 List of TRI Chemicals only includes Phosphorus (yellow or white). Yellow and white phosphorus, both allotropes of elemental phosphorus, are hazardous pollutants that spontaneously ignite in air. During the 2006 Annual Review, EPA identified that facilities were incorrectly reporting discharges of total phosphorus (i.e., the phosphorus portion of phosphorus-containing compounds) as phosphorus (yellow or white) (U.S. EPA, 2006). Therefore, EPA concluded that it was appropriate to exclude all phosphorus (yellow or white) discharges reported to TRI, and has made such adjustments to the data, beginning with the 2011 Annual Review (U.S. EPA, 2012). Total phosphorous (as reported in NPRI) is not included in the current List of TRI Chemicals (for reporting year 2015).

#### 4.2.6.2 NPRI Pollutant Analysis

EPA identified nine pollutants reported to NPRI in 2013 that were not reported to TRI. All but phosphorus were reported to NPRI by less than 20 percent of reporting facilities. Because phosphorus was reported to NPRI by 23 percent of facilities, EPA performed a more in-depth analysis of this pollutant.

No OCPSF facilities reported total phosphorus releases to TRI in 2013 because total phosphorus is not a TRI-listed pollutant. However, TRI does include one form of phosphorous on the 2013 List of TRI Chemicals, known as yellow or white phosphorus (U.S. EPA, 2014b). Historically, as part of its annual review process EPA excludes yellow or white phosphorus reported to TRI from its analyses because this elemental form of phosphorus is insoluble in water and is not the same form of phosphorus commonly measured in wastewater (U.S. EPA, 2012). According to NPRI reporting guidance, total phosphorus does not include yellow or white phosphorus; NPRI includes yellow or white phosphorus as a separate pollutant (Environment Canada, 2015).

EPA compared the magnitude of the phosphorus releases reported in NPRI to available 2013 DMR data for phosphorus. The 2013 NPRI total phosphorus releases ranged from 2 pounds to 2,200 pounds, as shown in Table 4-34. The total phosphorus discharges reported by

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

the top ten discharging OCPSF facilities in DMR range from 8,720 pounds to 190,000 pounds, as shown in Table 4-35. These top ten facilities account for approximately 90 percent of the total 2013 DMR total phosphorus discharges reported by OCPSF facilities. In general, total phosphorus releases reported by OCPSF facilities on DMRs in the U.S. are higher than total phosphorus releases reported in NPRI.

Though several facilities report total phosphorous discharges on DMRs, phosphorus does not have limitations under the OCPSF ELGs. In addition, EPA has not previously reviewed total phosphorous discharges for the OCPSF industry as part of recent annual reviews. Total phosphorous does not have an associated toxic weighting factor and subsequently does not appear in EPA’s TRA. See Section 2 of EPA’s 2015 Annual Review Report for more information on toxic weighting factors and EPA’s TRA (U.S. EPA, 2016a).

**Table 4-34. Top 2013 OCPSF Facilities Reporting Total Phosphorus Releases to NPRI**

Facility Name	Facility Location	Direct Pounds of Pollutant Released	Indirect Pounds of Pollutant Released	Total Pounds of Pollutant Released
London	London, ON	0	2,200	2,200
Welland Plant	Niagara Falls, ON	2,000	0	2,000
Jungbunzlauer Canada Inc.	Port Colborne, ON	1,820	0	1,820
Same	Lachine, QC	0	441	441
Novozymes Canada	Ottawa, ON	0	313	313
Mississauga Plant	Mississauga, ON	0	284	284
Virox Oakville	Oakville, ON	0	185	185
Burlington	Burlington, ON	0	165	165
Longford Mills Plant	Longford Mills, ON	7.50	0	7.50
Winnipeg (Ms54)	Winnipeg, MB	0	2	2
<b>Total</b>		<b>3,830</b>	<b>3,600</b>	<b>7,430</b>

Source: (Environment Canada, 2014).

Note: Facilities report pounds of pollutant released directly to surface waters or indirectly to POTWs.

**Table 4-35. Top 2013 OCPSF Facilities Reporting Total Phosphorus Discharges on DMRs**

Facility Name	Facility Location	Pounds of Pollutant Discharged
ICL-LP America, Inc.	Gallipolis Ferry, WV	190,000
Cytec Industries, Inc.	Willow Island, WV	54,700
Dupont Fayetteville Plant	Fayetteville, NC	48,700
Honeywell International, Inc. Hopewell Plant	Hopewell, VA	36,900
Dak Americas LLC Cape Fear Site	Leland, NC	17,600
MPM Silicones LLC	Friendly, WV	16,000
Eastman Chemical Co. South Carolina Operations	West Columbia, SC	13,700
Dupont Spruance Plant	Richmond, VA	12,900

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

**Table 4-35. Top 2013 OCPSF Facilities Reporting Total Phosphorus Discharges on DMRs**

Facility Name	Facility Location	Pounds of Pollutant Discharged
Sabir Innovative Plastics U.S. LLC	Washington, WV	10,600
Geo Specialty Chemicals Trimet Products Group	Allentown, PA	8,720
All other OCPSF dischargers of total phosphorus (44 additional facilities)		43,900
<b>Total</b>		<b>454,000</b>

Source: DMRLTOutput2013\_v1.

#### 4.2.7 Summary of the OCPSF Category Review

From its evaluation of total residual chlorine and nitrate discharges, EPA learned:

- *Total residual chlorine.* Total residual chlorine does not have limitations under the OCPSF ELGs; however, EPA identified 102 facilities with reported discharges on 2014 DMRs. The review of DMR average concentration data demonstrated that the median total residual chlorine concentration for OCPSF facilities falls just below the maximum (acute) concentration aquatic life water quality criterion (0.019 mg/L), but above the continuous (chronic) concentration aquatic life water quality criterion (0.011 mg/L) for total residual chlorine. This comparison provides an indication that the magnitude of any hazard associated with total residual chlorine discharges is relatively small.

The review of facility permit limits and discussion with state permitting authorities demonstrated that total residual chlorine is often added to cooling tower blowdown and other non-process wastewater to inhibit biological growth. Discussions with the IA DNR and NE DEQ suggest that (at least in these states), the permitted waste stream is subsequently dechlorinated using sodium bisulfate/bisulfite. Additionally, some facilities, specifically in Texas and West Virginia, combine sanitary wastewater with non-process or process wastewater. In Texas, state code establishes requirements for disinfection of facility effluent, and in these instances, facility permits establish a minimum total residual chlorine limit of 1.0 mg/L, often without establishing daily maximum and monthly average permit limits for total residual chlorine. Iowa, Nebraska, and West Virginia indicated that total residual chlorine limits are based on state water quality criteria, that consider mixing zones and other factors applied when deriving water quality-based permit limits.

Collectively, the data suggest that OCPSF facilities may be adding chlorine to disinfect cooling tower water or other non-process wastewater, or to disinfect commingled sanitary wastewater. In states other than Texas, facilities have daily maximum or monthly average total residual chlorine permit limits based on water quality criteria designed to protect the receiving water body.

- *Nitrate.* Nitrate does not have limitations under the OCPSF ELGs; however, EPA identified 120 facilities with reported releases to TRI in 2014. The review of available facility nitrate concentration data in DMR and data provided by facilities reporting to

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)*

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TRI demonstrated that the majority of nitrate concentrations are likely present at levels that could be reduced by further treatment based on a comparison to the baseline value and the national primary drinking water regulation for nitrate. The review of available treatment technology information in IWTT for industries other than OCPSF demonstrated that the effluent concentrations associated with these treatment technologies are generally lower than the 2014 DMR OCPSF facility median nitrate concentrations; however, the technologies reviewed did not specifically target nitrate removals and were not specifically applied to OCPSF wastewater.

- EPA’s review of NPRI identified nine pollutants that were reported to NPRI in 2013, but not to TRI. EPA focused its review on total phosphorus, as it was the only pollutant reported by more than 20 percent of the OCPSF facilities to the 2013 NPRI. TRI does not require facilities to report discharges of total phosphorus, therefore, EPA compared the magnitude of the 2013 NPRI discharges to total phosphorus discharges reported in 2013 DMR data. In general, total phosphorus releases reported by OCPSF facilities on DMRs in the U.S. are higher than total phosphorus releases reported in NPRI.

#### **4.2.8 OCPSF Category References**

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.2—Organic Chemicals, Plastics, and Synthetic Fibers (40 CFR Part 414)

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*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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### **4.3 Pulp, Paper, and Paperboard (40 CFR Part 430)**

As part of the 2015 Annual Review, EPA initiated a preliminary category review of the Pulp, Paper, and Paperboard (Pulp and Paper) Category because it ranked high, in terms of toxic-weighted pound equivalents (TWPE), in the final 2015 toxicity rankings analysis (TRA) (U.S. EPA, 2016a). EPA previously reviewed discharges from this category as part of the Preliminary and Final Effluent Guidelines Program Plans in 2004 – 2013 (U.S. EPA, 2004, 2006b, 2007, 2008, 2009b, 2011, 2012, 2014a, 2014b). During its 2006 Effluent Guidelines Program Plan development, EPA also conducted a detailed study of this category (U.S. EPA, 2006a).

From its 2015 TRA and preliminary category reviews, EPA decided that the Pulp and Paper Category warrants further review, specifically related to the discharges of lead and lead compounds (lead), mercury and mercury compounds (mercury), manganese and manganese compounds (manganese), and hydrogen sulfide (U.S. EPA, 2016b). The Pulp and Paper Category effluent limitations guidelines and standards (ELGs) do not regulate any of these pollutants. As part of this review, EPA further evaluated the discharges of these pollutants to:

- Understand the process operations at pulp and paper mills that generate the pollutants and how the mills are currently managing their wastewater.
- Understand how permitting authorities currently regulate discharges of the pollutants.
- Decide if the concentrations of lead, mercury, or manganese in effluent discharges are present at levels that could be reduced by further treatment.
- Review more recent data, specifically for hydrogen sulfide, to identify any changes in releases reported since the 2015 Annual Review.
- Identify advances in industrial wastewater treatment technology performance for reducing discharges of the pollutants.
- Identify additional pollutants potentially present in mill industrial wastewater discharges in the U.S., not currently captured in discharge monitoring report (DMR) data or Toxics Release Inventory (TRI) data.

Section 4.3.1 provides a background of the Pulp and Paper Category (40 CFR Part 430), and Section 4.3.2 provides a summary of the results of the previous ELG planning review related to the Pulp and Paper Category. Sections 4.3.3 through 4.3.6 present EPA’s current review approach and evaluation of the Pulp and Paper Category, including results from EPA’s continued review of the top pollutants in the category, evaluation of available treatment technology performance, and the results of the additional pollutant analysis. Section 4.3.7 summarizes EPA’s current review of the Pulp and Paper Category.

#### ***4.3.1 Pulp and Paper Category Background***

The Pulp and Paper Category includes mills that manufacture pulp from wood and other fibers, produce paper and paperboard from pulp, or convert paper and paperboard into products such as boxes, bags, and envelopes (U.S. EPA, 2009a). Pulp and paper mills vary in size, age, location, raw materials used, products manufactured, production processes, and effluent

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

treatment systems. The following subsections present an overview of the Pulp and Paper Category ELGs and their applicability.

#### 4.3.1.1 Pulp and Paper ELGs

EPA promulgated initial ELGs for the Pulp and Paper Category (40 CFR Part 430) in 1974 and 1977, amended the regulations in 1982 and 1986, and promulgated a major amendment covering toxic pollutants in certain subcategories in 1998. The 1998 "Cluster Rule" also promulgated toxic air emission standards (national emission standards for hazardous air pollutants (NESHAPs)) for the industry under the Clean Air Act. The ELGs regulate discharges from 12 subcategories, shown in Table 4-36. For a more detailed history of the existing regulation, see EPA’s 2006 detailed study report for the pulp and paper industry (U.S. EPA, 2006a).

**Table 4-36. Pulp and Paper ELGs Subcategories**

Subpart	Subcategory
A	Dissolving Kraft
B	Bleached Papergrade Kraft and Soda
C	Unbleached Kraft
D	Dissolving Sulfite
E	Papergrade Sulfite
F	Semi-Chemical
G	Mechanical Pulp
H	Non-Wood Chemical Pulp
I	Secondary Fiber Deink
J	Secondary Fiber Non-Deink
K	Fine and Lightweight Papers from Purchased Pulp
L	Tissue, Filter, Non-Woven, and Paperboard from Purchased Pulp

Source: 40 CFR Part 430

#### 4.3.1.2 Pulp and Paper Category Applicability

The Pulp and Paper regulation applies to any pulp, paper, or paperboard mill that discharges or may discharge process wastewater pollutants to the waters of the United States, or that introduces or may introduce process wastewater pollutants into a publicly owned treatment works (POTWs). For the purpose of its annual reviews, EPA considers the following 25 North American Industry Classification System (NAICS) codes and eight Standard Industrial Classification (SIC) codes to be part of the Pulp and Paper Category, as identified from the NAICS-Point Source Category (NAICS-PSC) and SIC-PSC crosswalks developed for the 304m Annual Review (U.S. EPA, 2009b). The 25 NAICS codes are:

- NAICS 321113: Sawmills
- NAICS 322110: Pulp Mills
- NAICS 322121: Paper (except Newsprint) Mills
- NAICS 322122: Newsprint Mills

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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- NAICS 322130: Paperboard Mills
- NAICS 322211: Corrugated and Solid Fiber Box Manufacturing
- NAICS 322212: Folding Paperboard Box Manufacturing
- NAICS 322214: Fiber Can, Tube, Drum, and Similar Products Manufacturing
- NAICS 322215: Nonfolding Sanitary Food Container Manufacturing
- NAICS 322221: Coated and Laminated Packaging Paper Manufacturing
- NAICS 322222: Coated and Laminated Paper Manufacturing
- NAICS 322224: Uncoated Paper and Multiwall Bag Manufacturing
- NAICS 322231: Die-Cut Paper and Paperboard Office Supplies Manufacturing
- NAICS 322291: Sanitary Paper Product Manufacturing
- NAICS 322299: All Other Converted Paper Product Manufacturing
- NAICS 322211: Corrugated and Solid Fiber Box Manufacturing
- NAICS 322212: Folding Paperboard Box Manufacturing;
- NAICS 322214: Fiber Can, Tube, Drum, and Similar Products Manufacturing
- NAICS 322215: Nonfolding Sanitary Food Container Manufacturing
- NAICS 322221: Coated and Laminated Packaging Paper Manufacturing
- NAICS 322222: Coated and Laminated Paper Manufacturing
- NAICS 322224: Uncoated Paper and Multiwall Bag Manufacturing
- NAICS 322231: Die-Cut Paper and Paperboard Office Supplies Manufacturing
- NAICS 322299: All Other Converted Paper Product Manufacturing
- NAICS 326112: Plastics Packaging Film and Sheet (including Laminated) Manufacturing

The eight SIC codes are:

- SIC 2653: Corrugated and Solid Fiber Boxes
- SIC 2655: Fiber Cans, Tubes, Drums, and Similar Products
- SIC 2656: Sanitary Food Containers, Except Folding
- SIC 2657: Folding Paperboard Boxes, Including Sanitary
- SIC 2671: Packaging Paper and Plastics Film, Coated and Laminated
- SIC 2672: Coated and Laminated Paper, Not Elsewhere Classified
- SIC 2674: Uncoated Paper and Multiwall Bags
- SIC 2679: Converted Paper and Paperboard Products, Not Elsewhere Classified

In 1980, EPA estimated that the Pulp and Paper ELGs applied to approximately 706 mills. Approximately 378 mills discharged directly to surface waters, 248 mills discharged indirectly to POTWs, and 12 mills had both direct and indirect discharges. Additionally, 54 mills recycled their wastewater (no discharge). EPA did not categorize the remaining 14 mills due to insufficient data (U.S. EPA, 1980).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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EPA identified 233 pulp and paper mills reporting water releases to TRI in 2014, with 158 mills reporting direct releases to surface waters, 67 mills reporting indirect releases to POTWs, and eight mills reporting both direct and indirect releases (*TRILTOOutput2014\_v1*). EPA identified 154 pulp and paper mills that submitted 2014 DMR data to the Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES) (*DMRLTOOutput2014\_v1*). While these numbers appear to show a decline in the number of pulp and paper mills discharging since the 1980s, due to the limitations of the DMR and TRI datasets, EPA does not have an exact count of how many mills currently are subject to the Pulp and Paper ELGs. See Section 2.1 for a discussion on the limitations of DMR and TRI data.

#### ***4.3.2 Summary of the Results of the 2015 Annual Review for the Pulp & Paper Category***

During the 2015 Annual Review, EPA identified TRI releases of lead, mercury, manganese, and hydrogen sulfide for further review. The paragraphs below summarize the results of EPA’s previous review regarding these four pollutants (U.S. EPA, 2016b).

- *Lead and mercury.* In 2013, 172 mills reported lead releases and 84 mills reported mercury releases, out of a total of 226 mills reporting water releases to TRI. The Pulp and Paper ELGs do not regulate either of these pollutants. EPA concluded that further investigation of these pollutants is appropriate to evaluate if concentrations are present in mill effluent at a level that may warrant further treatment.
- *Manganese.* In 2013, 112 mills reported releases of manganese out of a total of 226 mills reporting water releases to TRI. Further, it has been nearly 10 years since EPA conducted the Pulp and Paper detailed study in which it evaluated and compared manganese concentrations to treatable levels. For these reasons, EPA concluded that further investigation of manganese is appropriate to evaluate whether concentrations are present in mill effluent at levels that warrant further treatment.
- *Hydrogen sulfide.* Hydrogen sulfide was added as a TRI reporting requirement in 2012. In 2013, 98 mills reported hydrogen sulfide releases to TRI; seven mills accounted for 80 percent of the hydrogen sulfide releases, with the top mill accounting for 27 percent of the releases. The top mill confirmed their 2013 TRI hydrogen sulfide release data but stated that wastewater treatment system improvements had led to decreased hydrogen sulfide discharges in 2014. EPA contacted industry trade associations and learned that pulp and paper mills may use total sulfide, rather than dissolved sulfide concentrations, to calculate their hydrogen sulfide releases. Industry trade associations suggest that this may result in overestimates. One trade association has developed a new sampling system that may enable improved measurement of dissolved sulfides, and thus mitigate the overestimates of hydrogen sulfide releases in TRI. Due to the number of mills with hydrogen sulfide releases in TRI, lack of historical release data (releases have only been reported to TRI since 2012), and possible overestimation of hydrogen sulfide releases in TRI due to the current measurement convention, EPA concluded that it is appropriate to continue to monitor releases of hydrogen sulfide to evaluate whether they potentially represent a category-wide issue.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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### **4.3.3 Introduction to EPA’s Current Evaluation of Specific Pollutants in the Pulp & Paper Category**

For the current review, EPA evaluated the discharges of lead, mercury, manganese, and hydrogen sulfide to satisfy the objectives outlined above in Section 4.3. The Pulp and Paper ELGs do not regulate any of these pollutants. Specifically, EPA:

- Evaluated available 2014 DMR and TRI data<sup>26</sup> for the four pollutants, including concentration data reported on DMRs.
- Contacted several pulp and paper mills through two pulp and paper trade associations, the American Forest and Paper Association (AF&PA) and the National Council for Air and Stream Improvement (NCASI),<sup>27</sup> reporting releases of lead, mercury, manganese and hydrogen sulfide to TRI to gather information on process operations contributing to those releases, wastewater treatment technologies, and discharged concentrations.
- Reviewed the results and compared current discharge concentrations to relevant data collected during the 2006 pulp and paper detailed study.
- Researched the performance of available treatment technologies in the Industrial Wastewater Treatment Technology (IWTT) Database for the pollutants.
- Contacted state permitting authorities to further understand the development of pollutant permit limits and current processes for managing wastewater containing these pollutants.
- Reviewed available data in Canada’s National Pollutant Release Inventory (NPRI) to identify additional pollutants that may be present in pulp and paper mill wastewater discharges that are not reported in the U.S. under the TRI or DMR programs.

Table 4-37 compares the 2013 and 2014 TRI TWPE and the number of mills reporting releases of the four pollutants. Section 4.3.4 presents EPA’s analyses and results related to lead, mercury, and manganese. Section 4.3.5 presents EPA’s analyses and results related to hydrogen sulfide. Section 4.3.6 presents EPA’s analysis of the NPRI data.

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<sup>26</sup> EPA evaluated 2014 data because it represented the most current and complete DMR and TRI dataset available at the start of this review. Note that EPA evaluated 2013 DMR and TRI data in support of the 2015 Annual Review.

<sup>27</sup> AF&PA is the national trade association of the forest, pulp, paper, paperboard, and wood products industry. NCASI is a nonprofit research institute funded by the North American forest products industry, including pulp and paper mills.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-37. 2013 and 2014 TRI TWPE and Number of Pulp and Paper Mills Discharging Lead, Mercury, Manganese, and Hydrogen Sulfide**

Pollutant	2013 TRI Data		2014 TRI Data	
	Number of Mills <sup>a</sup>	TWPE	Number of Mills <sup>a</sup>	TWPE
Lead	172	47,700	175	49,100
Mercury	84	46,500	86	43,700
Manganese	112	318,000	110	455,000 <sup>b</sup>
Hydrogen Sulfide	98	1,190,000	95	1,230,000
<b>Total for All Pollutants Reported</b>	<b>226</b>	<b>1,820,000<sup>c</sup></b>	<b>233</b>	<b>3,000,000<sup>d</sup></b>

Sources: *TRILTOOutput2014\_v1*; *TRILTOOutput2013\_v1*.

Note: Sums of individual values may not equal the total presented due to rounding.

<sup>a</sup> Number of pulp and paper mills with TWPE greater than zero.

<sup>b</sup> The increase in the TRI manganese TWPE from 2013 to 2014 can be attributed to increases in reported manganese releases from the top mills.

<sup>c</sup> Total includes corrected data as identified during the 2015 Annual Review (U.S. EPA, 2016a).

<sup>d</sup> EPA did not complete a comprehensive quality review of the remainder of the 2014 TRI data; therefore, this total may include outliers. See Section 2.1 for more information.

#### **4.3.4 Pulp and Paper Category Review of Lead, Mercury, and Manganese Discharges**

During the 2006 detailed study, EPA identified metals as the second largest contributor (after dioxin) to the total toxic discharges (based on TWPE) for the Pulp and Paper Category. For this reason, EPA analyzed metals discharges, including discharges of lead, mercury, and manganese, from pulp and paper mills. As part of the study, EPA collected information about the concentrations of metals in pulp and paper mill discharges from NPDES Permit Renewal Application (Form 2C) data.<sup>28</sup> EPA compared the Form 2C concentrations to analytical method minimum levels (MLs),<sup>29</sup> shown in Table 4-38, calculated from the method detection limits (MDLs) listed in Method 200.7.<sup>30</sup> The comparison shows that lead and mercury were discharged at concentrations below their respective MLs, whereas manganese discharges were well above the ML. After further review of manganese discharges, EPA concluded that manganese concentrations are frequently higher in mill intake than in mill effluent, and that the expense of treatment technologies targeting manganese make such technologies infeasible. Therefore, pollution control strategies for manganese, such as minimizing spent pulping liquor losses, may

<sup>28</sup> When mills file applications for new or revised NPDES permits, they must complete a Form 2C, which requires analyses of certain pollutants. Effluent data requirements vary depending on the types of pollutants the permitting authority expects to be present in a mill's wastewater. As part of the 2006 Detailed Study, EPA obtained copies of Form 2Cs from 28 direct discharging mills, all in the eastern United States (U.S. EPA, 2006a).

<sup>29</sup> MLs represent the smallest quantity of a metal that can be reliably measured by the analytical method (U.S. EPA, 2006a).

<sup>30</sup> EPA calculated the MLs by multiplying the MDL by 3.18 and rounding to the nearest 2, 5, or 10x10<sup>n</sup> (where n is an integer). See Method 200.7, Revision 5: Trace Elements in Water, Solids, and Biosolids by Inductively Coupled Plasma-Atomic Emission Spectrometry.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

be the best strategy for reducing manganese discharges from pulp and paper mills<sup>31</sup> (U.S. EPA, 2006a).

**Table 4-38. Method ML and Form 2C Effluent Lead, Mercury, and Manganese Concentrations (µg/L)**

Pollutant	Method ML (µg/L) <sup>a</sup>	Form 2C Effluent Median Concentration (µg/L)
Lead	20	16.8
Mercury	0.2	0.1
Manganese	2	556

Source: (U.S. EPA, 2006a).

<sup>a</sup> Mercury method 245.1; Lead and manganese method 200.7.

For the current review, EPA obtained 2014 mill direct and indirect discharge concentrations of lead, mercury, and manganese from pulp and paper mills following the methodology outlined in Section 2.1.4. Specifically, EPA compiled average concentration data for lead, mercury, and manganese reported on DMRs. Additionally, EPA identified and contacted 15 mills (through AF&PA and NCASI, pulp and paper trade associations) to understand reported releases to TRI and gather underlying lead, mercury, and manganese concentration data that formed the basis for the TRI-reported direct and indirect releases of lead, mercury, and manganese (compiled in (ERG, 2016) and summarized below). Table 4-39 presents the mills EPA contacted along with information the mills provided regarding sources of metals in the wastewater. None of the mills have treatment technologies installed specifically targeting the removal of lead, mercury, or manganese. All mills listed in Table 4-39 provided underlying concentration data used to calculate lead, mercury, and manganese releases that they reported to TRI except Verso Paper in Bucksport, ME; this mill closed in 2015 (Schwartz & Wiegand, 2016).

EPA compared the DMR and TRI-based concentration data to information collected during the 2006 detailed study to provide a frame of reference for the magnitude of the discharges and to evaluate if concentrations have changed over the last 10 years. EPA also reviewed recent literature compiled in the IWTT Database to identify emerging treatment technologies that are being evaluated and/or implemented within the pulp and paper industry, or that are being evaluated and/or implemented in other industries, specifically for the removal of lead, mercury, or manganese (for more information on the IWTT Database, see Section 6.2 of this report). EPA presents its analysis of the concentration data and available treatment technology performance data for lead, mercury, and manganese in Sections 4.3.4.1 through 4.3.4.3, respectively.

From EPA’s discussions with AF&PA and NCASI, the trade associations also provided general information on the sources of lead, mercury, and manganese in pulp and paper mill wastewater discharges. The trade associations stated that trace amounts of these metals may be present in treated pulp mill wastewaters due to their presence in certain solid or liquid fuels or

<sup>31</sup> Additional pollution control strategies for manganese include dry disposal of green liquor dregs and lime mud, dry removal of soil (dirt) from logs prior to debarking and chipping, conversion from alum precipitation water treatment to reverse osmosis treatment, and minimizing paper machine losses (U.S. EPA, 2006a).

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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bark used in manufacturing operations. The metal compounds in fuels or bark may enter the wastewater treatment system after combustion if the mill uses wet air pollution control or has wet ash-handling operations. Other potential sources include metals found in process additives such as sulfuric acid, sodium hydroxide, or clay fillers used in papermaking. The mills do not add lead, mercury, or manganese during the manufacturing process (Schwartz & Wiegand, 2016).

To further understand the discharges and treatment of lead, mercury, and manganese, EPA contacted select states that have a high proportion of pulp and paper mills with lead, mercury, and manganese discharges, presented in Section 4.3.4.4.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-39. Mills Contacted to Obtain Underlying Concentration Data for Pollutant Releases Reported to TRI in 2014**

Mill Name	Mill Location	Direct/Indirect Discharger	Source of Metals in Wastewater	Pollutants for which the Mill Provided Concentration Data <sup>a</sup>	Mill Subcategory <sup>b</sup>
Appvion, Inc.	Roaring Spring, PA	Direct	No additional information provided.	Lead, Mercury, Manganese	B
Brunswick Cellulose LLC	Brunswick, GA	Direct	The mill performed a mercury minimization plan in 2006 and identified that sulfuric acid, hydrogen peroxide, and caustic soda represented greater than 99.6 percent of the total mercury brought into the mill in process chemicals. Consequently, the mill has requested low-level mercury reports from suppliers and only buys from suppliers that demonstrate mercury concentrations in their chemicals are less than 25 percent of the industry average.	Lead, Mercury, Manganese	B
Domtar Ashdown Mill	Ashdown, AR	Direct	No additional information provided.	Lead, Mercury, Manganese	B
Georgia-Pacific Crossett	Crossett, AR	Direct	A large source of mercury and manganese at the mill is due to the mercury content in the surface water that the mill utilizes for process water. The mill has a mercury minimization plan and works with the City of Crossett to decrease mercury levels. Lead discharges likely result from source wood.	Lead, Mercury, Manganese	B
Georgia-Pacific Monticello LLC	Monticello, MS	Direct	No additional information provided.	Lead, Mercury, Manganese	C
International Paper	Prattville, AL	Direct	No additional information provided.	Lead, Manganese	C
International Paper	Valliant, OK	Direct	No additional information provided.	Lead, Manganese	C
International Paper Georgetown Mill	Georgetown, SC	Direct	No additional information provided.	Lead, Mercury, Manganese	B
International Paper Texarkana Mill	Queen City, TX	Direct	No additional information provided.	Lead, Mercury, Manganese	Not provided

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-39. Mills Contacted to Obtain Underlying Concentration Data for Pollutant Releases Reported to TRI in 2014**

Mill Name	Mill Location	Direct/Indirect Discharger	Source of Metals in Wastewater	Pollutants for which the Mill Provided Concentration Data <sup>a</sup>	Mill Subcategory <sup>b</sup>
PH Glatfelter Co. Chillicothe Mill	Chillicothe, OH	Direct	Lead and manganese discharges result from source wood; mercury discharges result from coal-fired boilers.	Lead, Mercury, Manganese	B
SD Warren Co.	Skowhegan, ME	Direct	Mercury discharges result from use of sulfuric acid as a process chemical. The mill now requires the supplier to submit an analysis of mercury content on a routine basis.	Lead, Mercury, Manganese	B
Verso Paper Bucksport Mill	Bucksport, ME	Direct	Mill closed in 2015, no information received.		
Blandin Paper Co.	Grand Rapids, MN	Indirect	No additional information provided.	Lead, Mercury	G
Graphic Packaging International, Inc.	Macon, GA	Indirect	No additional information provided.	Lead, Mercury, Manganese	C
Luke Paper Co.	Luke, MD	Indirect	The mill identified that the source of lead discharges is lead projectiles used in the lime kiln to break up chunks of lime.	Lead, Mercury	B

Sources: (Schwartz & Wiegand, 2016).

<sup>a</sup> EPA compiled the concentration data provided by the mills into a spreadsheet to support the analyses discussed in this section (ERG, 2016).

<sup>b</sup> The mills provided the applicable subcategory. Subcategories include: Subcategory B: Bleached Papergrade Kraft and Soda; Subcategory C: Unbleached Kraft Subcategory; Subcategory G: Mechanical Pulp.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

#### 4.3.4.1 Evaluation of Lead Discharge Concentration

For this analysis, EPA compiled lead concentration data for a total of 21 pulp and paper mills; seven mills reported data on 2014 DMRs, 11 mills reported direct releases to TRI, and three mills reported indirect releases to TRI in 2014. Per the methodology outlined in Section 2.1.4, EPA calculated yearly average concentrations from these mills to use in subsequent analyses (ERG, 2016). EPA compared current discharge concentrations to relevant data collected during the 2006 study as well as available treatment technology performance data in IWTT.

##### *Evaluation of Direct Discharge Lead Concentrations*

EPA compared the 2014 lead concentration data for direct discharging pulp and paper mills to the Form 2C median concentration identified during the 2006 study and the Method 200.7 ML for lead.

Table 4-40 summarizes the 2014 direct discharge lead concentration data, including the minimum, median, and maximum concentrations, and number of data points for the DMR and TRI data. As shown, the median concentrations for both the DMR and TRI data are an order of magnitude below the 2006 Form 2C median concentration and Method 200.7 ML. The data suggest that lead discharges from direct discharging mills are below treatable levels, consistent with information from the 2006 detailed study.

**Table 4-40. Comparison of Pulp and Paper Mill 2014 Average Direct Discharge Lead Concentration Data to 2006 Form 2C Data and the Method ML**

Data Type	Number of Data Points <sup>a</sup>	Average Lead Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Pulp and Paper Mill DMR Data	7	0.00497	2.08	5
2014 Pulp and Paper Mill TRI Data	11	Non-detect	1	250 <sup>b</sup>
<b>2006 Form 2C Median Concentration for Lead</b>	<b>16.8 µg/L</b>			
<b>Method 200.7 ML for Lead</b>	<b>20 µg/L</b>			

Sources: (ERG, 2016; U.S. EPA, 2006a).

<sup>a</sup> The number of data points represents the number of outfalls, not mills. Some mills have more than one outfall.

<sup>b</sup> The maximum concentration data point is an outlier. According to Georgia-Pacific Crossett in Crossett, AR, lead was non-detect; however, in accordance with TRI guidance, the mill based its annual loads reported to TRI on a release concentration of 0.25 mg/L (250 µg/L), which they took to represent half the detection limit (Schwartz & Wiegand, 2016). EPA notes that the detection limit the mill uses in its analysis and reporting to TRI is also higher than the Method 200.7 ML for lead.

##### *Evaluation of Indirect Discharge Lead Concentrations*

The majority of pulp and paper mills are direct dischargers; therefore, the dataset is limited for indirect discharging mills. To evaluate indirect discharges of lead, EPA compared current lead concentrations in effluent from three mills to the Method 200.7 ML concentration for lead. The three average concentrations shown in Table 4-41 all fall below the Method 200.7 ML. Consistent with the data for direct discharges, these data suggest that indirect lead discharges are below treatable levels.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-41. Comparison of Pulp and Paper Mill 2014 Average Indirect Discharge Lead Concentration Data to the Method ML**

Mill Name and Location	Average Lead Concentration
Luke Paper Co., Luke, MD	5 µg/L
Blandin Paper, Co., Grand Rapids, MN	11.2 µg/L
Graphic Packaging International Inc., Macon, GA	16 µg/L
<b>Method 200.7 ML for Lead</b>	<b>20 µg/L</b>

Source: (ERG, 2016; U.S. EPA, 2006a).

***Treatment of Lead in Pulp and Paper Wastewater***

EPA queried the IWTT Database for performance data on the treatment of lead, not specifically limiting its search to pulp and paper mills. Table 4-42 summarizes the identified treatment systems and their effectiveness. EPA did not identify any studies specifically citing lead removal in the pulp and paper industry. However, other industries, such as metal finishing and ore mining and dressing, remove metals using membrane bioreactors, membrane filtration, and adsorptive media. Three of the four studies with lead removal data show lead effluent concentrations ranging from <1 to 4 µg/L and removal efficiencies ranging from 76.7 to 96.7 percent. These concentrations are similar to the 2014 median lead concentrations identified during this review and are well below the Method 200.7 ML for lead (20 µg/L). Therefore, the studies do not demonstrate the availability of technologies that can reduce lead concentrations to below levels currently measured in pulp and paper mill discharges.

**Table 4-42. Summary of Wastewater Treatment Technology Data for Lead in IWTT**

Wastewater Treatment Technology (Order of Unit Processes)	Effluent Lead Concentration (µg/L) <sup>a</sup>	Percent Removal	Industry	Treatment Scale	Reference
Membrane Bioreactor	1	76.7%	Metal finishing	Pilot	(Buckles, et al., 2003)
Bag and Cartridge Filtration, Oil/Water Separation, Flow Equalization, and Membrane Filtration	4	95.0%		Pilot	(Pugh, et al., 2014)
Membrane Bioreactor and Aeration	52.8	96.7%	Ore mining and dressing	Pilot	(Progress, et al., 2012)
Mechanical Pre-Treatment, Flow Equalization, Oil/Water Separation, Membrane Bioreactor, and Adsorptive Media	< 1	> 76.7%	Transportation equipment cleaning	Full	(Buckles, et al., 2007)

NR – Not Reported

<sup>a</sup> Studies reported effluent concentration data in mg/L. EPA converted the data to µg/L to facilitate comparison with mill effluent lead concentrations.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

#### 4.3.4.2 Evaluation of Mercury Discharge Concentrations

EPA compiled mercury concentration data for 26 pulp and paper mills; 14 from data reported on 2014 DMRs, nine from mills reporting direct releases to TRI, and three from mills reporting indirect releases to TRI in 2014. Per the methodology outlined in Section 2.1.4, EPA calculated the yearly average concentrations from these mills to use in subsequent analyses (ERG, 2016). EPA compared current discharge concentrations to relevant data collected during the 2006 study as well as available treatment technology performance data in IWTT.

##### *Evaluation of Direct Discharge Mercury Concentrations*

EPA compared the 2014 mercury concentration data for direct discharging pulp and paper mills to the Form 2C median concentration identified during the 2006 detailed study and the Method 245.1 ML.

Table 4-43 summarizes the 2014 direct discharge mercury concentration data, including the minimum, median, and maximum concentrations and number of data points for the DMR and TRI data. As shown, the median concentrations for both the DMR and TRI data fall two orders of magnitude below the 2006 Form 2C median concentration and Method 245.1 ML. The maximum DMR concentration is only slightly above the Method 245.1 ML. The data suggest that mercury discharges from direct discharging mills are below treatable levels, consistent with information from the 2006 detailed study.

**Table 4-43. Comparison of Pulp and Paper Mill 2014 Average Direct Discharge Mercury Concentration Data to 2006 Form 2C Data and the Method ML**

Data Type	Number of Data Points <sup>a</sup>	Average Mercury Concentrations (µg/L)		
		Minimum	Median	Maximum
2014 Pulp and Paper Mill DMR Data	14	0.000411	0.00361	0.231
2014 Pulp and Paper Mill TRI Data	9	Non-detect	0.00397	0.007
<b>2006 Form 2C Median Concentration for Mercury</b>		<b>0.1 µg/L</b>		
<b>Method 245.1 ML for Mercury</b>		<b>0.2 µg/L</b>		

Source: (ERG, 2016; U.S. EPA, 2006a).

<sup>a</sup> The number of data points represents the number of outfalls, not mills. Some mills have more than one outfall.

##### *Evaluation of Indirect Discharge Mercury Concentrations*

The majority of pulp and paper mills are direct dischargers; therefore, the dataset is limited for indirect discharging mills. To evaluate indirect discharges of mercury, EPA compared current mercury concentrations in effluent from three mills to the Method 245.1 ML concentration for mercury. As shown in Table 4-44, two of the three average TRI concentrations fall below the Method 245.1 ML. One average concentration is the same order of magnitude but falls above the Method 245.1 ML. Consistent with the data for direct discharges, these limited data suggest that mercury discharges from indirect mills are generally below treatable levels.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-44. Comparison of Pulp and Paper Mill 2014 Average Indirect Discharge Mercury Concentration Data to the Method ML**

Mill Name and Location	Average Mercury Concentration
Verso/Luke Paper Co., Luke, MD	0.0996 µg/L
Blandin Paper Co., Grand Rapids, MN	0.108 µg/L
Graphic Packaging International Inc., Macon, GA	0.25 µg/L
<b>Method 245.1 ML for Mercury</b>	<b>0.2 µg/L</b>

Source: (ERG, 2016; U.S. EPA, 2006a).

***Treatment of Mercury in Pulp and Paper Wastewater***

EPA queried the IWTT Database for performance data on the treatment of mercury, not specifically limiting its search to pulp and paper mills. Table 4-45 summarizes the identified treatment systems and their effectiveness. EPA did not identify any studies specifically citing mercury removal in the pulp and paper industry. However, other industries, such as petroleum refining and steam electric power generating, remove metals using granular-media filtration, constructed wetlands, membrane bioreactors, and adsorptive media. Two of the three studies with mercury removal data show mercury effluent concentrations of 0.0073 µg/L and <1 µg/L and removal efficiencies ranging from 62.9 to 92.5 percent. The 2014 median mercury concentrations identified during this review (0.00361 µg/L and 0.00397 µg/L, respectively) are similar to the concentrations identified from studies in IWTT. Therefore, the studies do not demonstrate the availability of technologies that can reduce mercury concentrations to below levels currently measured in pulp and paper mill discharges.

**Table 4-45. Summary of Wastewater Treatment Technologies for Mercury in IWTT**

Wastewater Treatment Technology (Order of Unit Processes)	Effluent Mercury Concentration (µg/L) <sup>a</sup>	Percent Removal	Industry	Treatment Scale	Reference
Granular-Media Filtration	0.0073	91.8%	Petroleum refining	Pilot	(Pulliam, et al., 2010)
Constructed Wetlands	NR	92.5%	Steam electric power generating	Pilot	(Morrison, et al., 2011)
Mechanical Pre-Treatment, Flow Equalization, Oil/Water Separation, Membrane Bioreactor, and Adsorptive Media	< 1	> 62.9%	Transportation equipment cleaning	Full	(Buckles, et al., 2007)

NR – Not Reported

<sup>a</sup> Some studies reported effluent concentration data in mg/L. EPA converted the data to µg/L to facilitate comparison with mill effluent mercury concentrations.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

#### 4.3.4.3 Evaluation of Manganese Discharge Concentrations

For this analysis, EPA compiled manganese concentration data for 14 pulp and paper mills; two from data reported on 2014 DMRs, 11 from mills reporting direct releases to TRI, and one from a mill reporting indirect releases to TRI in 2014. Per the methodology outlined in Section 2.1.4, EPA calculated the yearly average concentrations from these mills to use in subsequent analyses (ERG, 2016). EPA compared current discharge concentrations to relevant data collected during the 2006 study as well as available treatment technology performance data in IWTT. EPA also followed up with the two pulp and paper trade associations, AF&PA and NCASI, to gather additional information on sources, concentrations discharged, and treatment technologies for manganese, discussed below.

##### *Evaluation of Direct Discharge Manganese Concentrations*

EPA compared the 2014 manganese concentration data for direct discharging pulp and paper mills to the Form 2C median concentration identified during the 2006 detailed study and the Method 200.7 ML for manganese.

Table 4-46 summarizes the 2014 direct discharge manganese concentration data, including the minimum, median, and maximum concentrations and number of data points for the DMR and TRI data. As shown, the median concentrations for both the DMR and TRI data are two orders of magnitude above the Method 200.7 ML, but similar to the 2006 Form 2C median concentration. These data suggest that manganese may generally be present in discharges at concentrations that could be controlled by further treatment. This is consistent with information from the 2006 detailed study; however, at that time EPA concluded that manganese concentrations are frequently higher in mill intake than in mill effluent and that costs of treatment technologies targeting manganese make such technologies infeasible. Therefore, pollution control strategies for manganese, such as minimizing spent pulping liquor losses, may be the best approach for reducing manganese discharges from pulp and paper mills<sup>32</sup> (U.S. EPA, 2006a).

**Table 4-46. Comparison of Pulp and Paper Mill 2014 Average Direct Discharge Manganese Concentration Data to 2006 Form 2C Data and the Method ML**

Data Type	Number of Data Points <sup>a</sup>	Manganese Concentrations (ug/L)		
		Minimum	Median	Maximum
2014 Pulp and Paper Mill DMR Data	7 <sup>a</sup>	17	160	840
2014 Pulp and Paper Mill TRI Data	11	0.0000339	740	2,200
<b>2006 Form 2C Median Concentration for Manganese</b>		<b>556 ug/L</b>		
<b>Method 200.7 ML for Manganese</b>		<b>2 ug/L</b>		

Source: (ERG, 2016; U.S. EPA, 2006a).

<sup>a</sup> The number of data points represents the number of outfalls, not mills. Some mills have more than one outfall.

<sup>32</sup> Additional pollution control strategies for manganese include dry disposal of green liquor dregs and lime mud, dry removal of soil (dirt) from logs prior to debarking and chipping, conversion from alum precipitation water treatment to reverse osmosis treatment, and minimizing paper machine losses (U.S. EPA, 2006a).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

### ***Evaluation of Indirect Discharge Manganese Concentrations***

EPA obtained only one indirect discharge manganese concentration value from the pulp and paper mills contacted. Graphic Packaging International Inc., Macon, GA reported a concentration of 0.88 mg/L (880 ug/L), which is more than two orders of magnitude higher than the manganese Method 200.7 ML, 0.002 mg/L, but similar to the 2006 Form 2C median concentration. This data point is consistent with the results of the analysis of direct discharges, discussed above.

### ***Additional Review of Manganese Discharges***

As shown above, the median direct and indirect discharge manganese concentrations are two orders of magnitude above the Method 200.7 ML, but similar to the 2006 Form 2C median concentration, which suggest that manganese may generally be present in discharges at concentrations that could be controlled by further treatment. Therefore, EPA followed up with the pulp and paper trade associations to gather additional information on manganese sources, concentrations discharged, and treatment technologies.

The pulp and paper trade associations compiled manganese concentration data for pulp and paper mills from several data sources, including NCASI files, DMRs, Form 2C data, TRI, and NPRI. Table 4-47 presents the additional manganese concentration data for pulp and paper mills. EPA compared the additional concentration data to the Method 200.7 ML for manganese to provide a frame of reference for the magnitude of the discharges. EPA also compared the concentration data to ten times the Method 200.7 ML to assess whether the concentrations are generally at a level substantial enough for further treatment, presented in Table 4-47. Consistent with EPA’s analysis of concentration data, the minimum concentrations across all datasets are above the ML, and the median concentrations across all datasets are generally at least an order of magnitude or more greater than ten times the ML for manganese.

**Table 4-47. Comparison of Pulp and Paper Mill Manganese Effluent Concentration Data from Trade Associations to the MDL**

Data Source	Reporting Year	Number of Mills	Manganese Concentrations (µg/L)		
			Minimum	Median	Maximum
NCASI Data	1998	8	17	NA	1,400
DMR <sup>a</sup>	2014	3	4	88	250
TRI <sup>a</sup>	2014	10	747	1,220	2,240
Form 2C	1997-2016	64	11	435	3,670
NPRI	2014	18	110	907	1,880
<b>Method 200.7 ML for Manganese</b>			<b>2 µg/L</b>		
<b>10x Method 200.7 ML for Manganese</b>			<b>20 µg/L</b>		

Source: (NCASI, 2017).

NA: Not applicable; trade associations did not provide the median concentration data for the NCASI data source.

<sup>a</sup> The 2014 DMR and TRI concentration data shown in Table 4-46 differs from the trade association data due to reviewing different subsets of data. For example, the trade associations reviewed the top ten mills with manganese releases in TRI in 2014 and multiplied the reported loads by available flow data to calculate concentrations, while EPA reviewed concentration data provided by a subset of mills contacted shown in Table 4-46.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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EPA notes several assumptions and limitations of the data compiled by the trade associations that include (NCASI, 2017):

- For TRI and NPRI data, the trade association’s review focused on mills with the highest reported discharge loads of each metal.
- Because facilities report total loads to TRI and NPRI, and flow data are not available in these datasets, the trade associations estimated concentrations for these facilities based on readily available NCASI data on effluent flow and the reported TRI and NPRI loads. The NCASI, DMR, and Form 2C data represent the full range of actual concentration data reported.
- DMR data were limited because few pulp and paper mill NPDES permits require monitoring of manganese.
- Form 2C data collection is informal and cannot be assumed to represent a cross-section of the industry.

EPA also reviewed sources and treatment information provided by the pulp and paper trade associations. According to the trade associations, manganese concentrations in mill discharges may result from (NCASI, 2017):

- Intake water
- Wood furnishes
- Energy generation (e.g., coal, oil)
- Processing additives (e.g., phosphoric acid, sulfuric acid, alum, dyes, ammonia polyphosphate, clay)
- Other raw materials used by the mill

A primary source of manganese is wood furnish, including virgin fiber (e.g., chips or sawdust), old corrugated containers, and recycled papers (e.g., newsprint, magazines, copy paper). The amount of manganese in wood furnishes varies by wood type and furnish source; however, overall manganese levels in wood furnishes reported in literature and datasets from trade associations range from 2,920 to 110,000 parts per billion (ppb) (or  $\mu\text{g/L}$ ). Manganese may also result from coal- and oil-fired energy generation, which is relevant at mills with wet ash handling systems or mills using wet air pollution control devices that have a liquid purge (NCASI, 2017).

The trade associations also reviewed and provided information on intake water manganese concentrations, based on an evaluation of 2000 to 2015 data from EPA’s Water Quality eXchange (WQX) for the Hydrologic Unit Codes (HUCs) from the closest upstream monitoring locations for mills with DMR, Form 2C, and/or TRI data. From this review, trade associations identified that median upstream ambient water manganese concentrations ranged from 5.6 to 320  $\mu\text{g/L}$  and suggested that a focused study would be needed to evaluate whether intake water is a significant contributor to manganese concentrations in mill effluent (NCASI, 2017). Upstream ambient manganese concentrations reported by the trade associations are lower than, but on the same order of magnitude as, the median effluent concentrations reported in Table 4-47.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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***Treatment of Manganese in Mill Pulp and Paper Wastewater***

According to the trade associations, sedimentation and biological secondary treatment are used in the pulp and paper industry and at POTWs to remove biochemical oxygen demand (BOD) and total suspended solids (TSS) (NCASI, 2017). Manganese may be incidentally removed through precipitation, adsorption, and biological uptake; however, pulp and paper mills do not operate treatment technologies dedicated to the removal of manganese. From their review of industry literature, trade associations identified that municipal treatment plants with primary and secondary treatment generally remove less than 50 percent of manganese (NCASI, 2017).

EPA also queried the IWTT Database for performance data on the treatment of manganese, not specifically limiting its search to pulp and paper mills. Table 4-48 summarizes the identified treatment systems and their effectiveness. EPA did not identify any studies specifically citing manganese removal in the pulp and paper industry. However, other industries, such as ore mining and dressing and petroleum refining, remove metals using biological treatment, advanced filtration, and ion exchange technologies. The reviewed studies reported manganese effluent concentrations ranging from less than 10 µg/L to 1,770 µg/L, and removal efficiencies ranging from 53.1 percent to 98.6 percent. The effluent concentrations identified from IWTT fall within the range of trade association median effluent data (88 µg/L to 1,220 µg/L) and are similar to the median 2014 DMR and TRI concentration data (160 µg/L and 740 µg/L, respectively). Therefore, the studies do not conclusively demonstrate that the available technologies can reliably reduce manganese concentrations to below levels currently measured in pulp and paper mill discharges.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-48. Summary of Wastewater Treatment Technologies for Manganese in IWTT**

Parameter	Wastewater Treatment Technology (Order of Unit Processes)	Effluent Concentration (µg/L) <sup>a</sup>	Percent Removal	Industry	Treatment Scale	Reference
Manganese	Aerobic Fixed Film Biological Treatment, Chemical Precipitation, and Powdered Activated Carbon	150	53.1%	Metal finishing	Pilot	(Ahmad, et al., 2010)
	Chemical Precipitation, Dissolved Air Flotation, and Granular-Media Filtration	230	98.6%	Ore mining and dressing	Pilot	(Colic & Hogan, 2012)
	Membrane Bioreactor and Aeration	1,770	82.0%		Pilot	(Progress, et al., 2012)
	Constructed Wetlands	NR	92.5%	Steam electric power generating	Pilot	(Morrison, et al., 2011)
Manganese, total	Membrane Filtration, Ion Exchange, and Reverse Osmosis	<10	> 83.3%	Petroleum refining	Pilot	(Ginzburg & Cansino, 2009)
	Membrane Bioreactor	10	NR	Canned and Preserved Fruits and Vegetables Processing	Pilot	(Riedel, et al., 2015)
	Anaerobic Digestion, Membrane Bioreactor	100	NR		Pilot	

<sup>a</sup> Some studies reported effluent concentration data in mg/L. EPA converted the data to µg/L to facilitate comparison with mill effluent manganese concentrations.

NR – Not Reported

#### **4.3.4.4 Summary of Permit Reviews and Information Obtained from States Regarding Discharges of Lead, Mercury, and Manganese**

As part of this review, EPA contacted two state permitting authorities, the Wisconsin Department of Natural Resources (WI DNR) and the Connecticut Department of Energy and Environmental Protection (CT DEEP), that have a high proportion of pulp and paper mills with DMR discharges of lead, mercury, and/or manganese. EPA made these contacts to help inform its understanding of the pollutant discharges. Specifically, EPA collected additional information on the development of permit limits.

When a mill submits a permit application with lead, mercury, or manganese concentration data, in addition to applying any relevant technology-based limitations (in this case, any applicable Pulp and Paper ELGs) both states will calculate a reasonable potential for the pollutant to be present in the wastewater at a level requiring a water quality-based permit limit. The water quality-based permit limit is calculated using water quality criteria (Mauger, 2016; Zimmerman, 2016).

In Wisconsin, the water quality standards for lead include acute toxicity criteria (ATC), chronic toxicity criteria (CTC), and human threshold criteria (HTC). The water quality standards for mercury include ATC, CTC, HTC, and a wildlife criterion. The mercury wildlife criterion is the most stringent, so most permit limits are based on this value. Wisconsin does not have a water quality standard for manganese, but they do have a drinking water standard. If a mill has 11 or more detections of a pollutant in their permit application sampling data, WI DNR performs a reasonable potential analysis. If the statistical value calculated is greater than the water quality standard, the pollutant limit will be added to the mill permit. If the application has fewer than 11 detections, the state will determine if the average of the available concentration data is greater than one-fifth of the water quality standard, whereupon the pollutant limit will be added to the mill permit (Zimmerman, 2016).

The WI DNR contact indicated that most of the rivers in Wisconsin have high background mercury concentrations and that most pulp and paper mill mercury discharges result from the influent water; no mercury is added during the pulp and paper manufacturing process (Zimmerman, 2016).

The CT DEEP contact did not provide details on the water quality standards for lead, mercury, or manganese in Connecticut (Mauger, 2016).

The CT DEEP contact provided mill permits and fact sheets for three pulp and paper mills, and the Wisconsin DNR contact provided mill permits and fact sheets for four pulp and paper mills. Table 4-49 presents a summary of the permit information for these seven pulp and paper mills, including the lead, mercury, and manganese permit limits. As shown, only one mill has permit limits for lead, two mills have permit limits for mercury, and no mills have permit limits for manganese, although three mills have manganese monitoring requirements.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-49. Summary of Permit Information for Connecticut and Wisconsin Pulp and Paper Mills**

NPDES ID	Mill Name	Mill Location	Lead Limits			Mercury Limits			Manganese Limits		
			Outfall Number	Monthly Average Limit (mg/L)	Daily Max Limit (mg/L)	Outfall Number	Monthly Average Limit (mg/L)	Daily Max Limit (mg/L)	Outfall Number	Monthly Average Limit (mg/L)	Daily Max Limit (mg/L)
CT0026476	Algonquin Power Cogeneration Facility	Windsor Locks	001-1, 002-1	Monitoring only	None	None	None	None	001-1, 002-1	Monitoring only	None
CT0000434	Ahlstrom Nonwovens	Windsor Locks	006-1, 008-1	Monitoring only	None	None	None	None	002-1, 003-1, 003A, 004-1, 005-1	Monitoring only	None
CT0003212	Kimberly-Clark	New Milford	002-1	0.00675	0.0167	None	None	None	None	None	None
WI0037991	Stora Enso North America Water Quality Center	Wisconsin Rapids, WI	None	None	None	022	None	0.000038	None	None	None
WI0002810	Packaging Corp of America	Tomahawk, WI	None	None	None	003	None	0.000042	None	None	None
WI0003620	Domtar	Point Edwards, WI	005	Monitoring only <sup>a</sup>	None	013	None	0.000018	005	Monitoring Only <sup>a</sup>	None
WI0003212	Flambeau River Papers	Park Falls, WI	None	None	None	001	Monitoring Only	None	None	None	None

Source: (CT DEEP, 2009, 2011a, 2011b; WI DNR, 2010a, 2010b, 2013, 2015)

<sup>a</sup> The permit lists monitoring requirements for dissolved lead and dissolved manganese.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

#### 4.3.5 Pulp & Paper Category Review of Hydrogen Sulfide Discharges

For this analysis, EPA evaluated 2014 TRI data to identify any changes in releases from those reported in the 2013 TRI data (which EPA evaluated for the 2015 Annual Review). As shown in Table 4-50, hydrogen sulfide releases reported to TRI have slightly, but consistently increased from 2012 to 2014. EPA reviewed the 2014 TRI data in more detail and identified that five mills account for approximately 70 percent of the reported hydrogen sulfide releases, shown in Table 4-51.

**Table 4-50. Summary of 2012-2014 TRI Hydrogen Sulfide Releases**

Year	Direct Releases (pounds)	Direct TWPE	Indirect Releases (pounds)	Indirect TWPE	Total Releases (pounds)	Total TWPE
2012	408,000	1,140,000	3,760	10,500	412,000	1,150,000
2013	419,000	1,170,000	4,680	13,100	424,000	1,190,000
2014	437,000	1,220,000	2,430	6,790	440,000	1,230,000

Source: Water Pollutant Loading Tool

Note: Sums of individual values may not equal the total presented, due to rounding.

**Table 4-51. Top Mills Reporting 2014 TRI Hydrogen Sulfide Releases**

Mill Name	Mill Location	Pounds of Pollutant Released	Pollutant TWPE	Percent of Category TWPE
Georgia-Pacific Monticello	Monticello, MS	141,000	394,000	32.0%
Alabama River Cellulose LLC	Perdue Hill, AL	49,300	138,000	11.2%
Brunswick Cellulose LLC	Brunswick, GA	46,900	131,000	10.7%
Rayonier Performance Fibers Jesup Mill	Jesup, GA	40,800	114,000	9.3%
Georgia Pacific Cedar Springs LLC	Cedar Springs, GA	31,700	88,600	7.2%
All other Pulp and Paper Category mills reporting hydrogen sulfide releases (90 additional mills).		130,000	365,000	29.6%
<b>Total</b>		<b>440,000</b>	<b>1,230,000</b>	<b>100%</b>

Source: *TRILTOOutput2014\_v1*

Note: Sums of individual values may not equal the total presented, due to rounding.

As mentioned above, NCASI indicated during the 2015 Annual Review that it was developing a new sampling system that might enable more accurate measurement of hydrogen sulfide, thereby reducing overestimations reported to TRI. As part of the current review, EPA contacted the pulp and paper trade associations, AF&PA and NCASI, to discuss progress on the sampling system, as well as an apparent further increase in releases of hydrogen sulfide. NCASI reported that they have not yet updated sampling methods (Schwartz & Wiegand, 2016). See the 2015 Annual Review Report for further details on NCASI’s sampling methods and EPA’s review of hydrogen sulfide releases (U.S. EPA, 2016a).

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

AF&PA and NCASI also contacted the top mills reporting 2014 TRI hydrogen sulfide releases, shown in Table 4-51, to further understand the releases. Georgia-Pacific, which owns four of the mills listed in Table 4-51, confirmed that all hydrogen sulfide release calculations for the four mills resulted from wastewater sampling and measurements of total sulfide in the wastewater. However, the original calculations did not take into account the effluent pH and resulting proportion that hydrogen sulfide that would be present in the aqueous form at the measured effluent pH. Georgia-Pacific updated the hydrogen sulfide calculations for all four mills based on this observation. Additionally, the Georgia-Pacific Monticello mill confirmed that the 2014 TRI hydrogen sulfide release mistakenly used a concentration from sampling that occurred in 2011 (Schwartz & Wiegand, 2016). Table 4-52 presents revised pounds of released hydrogen sulfide and TWPE, reflecting corrected data provided by Georgia-Pacific.

AF&PA and NCASI also contacted Rayonier Performance Fibers in Jesup, GA. The mill identified a mathematical error in the hydrogen sulfide calculations that caused the reported discharges to be off by a factor of ten (Schwartz & Wiegand, 2016). Table 4-52 presents revised pounds and TWPE for the Rayonier Performance Fibers mill.

These corrections to the 2014 hydrogen sulfide data decrease the total hydrogen sulfide TWPE for the Pulp and Paper Category from 1,230,000 to 580,000. This new information suggests that other hydrogen sulfide releases reported to TRI may be overestimated, potentially substantially.

**Table 4-52. Revised Data for Top Mills Reporting 2014 TRI Hydrogen Sulfide Releases**

Mill Name	Mill Location	Pounds of Pollutant Released	Pollutant TWPE	Percent of Category TWPE
Georgia-Pacific Monticello	Monticello, MS	8,190	22,900	4.0%
Alabama River Cellulose LLC	Perdue Hill, AL	39,500	111,000	19.1%
Brunswick Cellulose LLC	Brunswick, GA	7,370	20,600	3.6%
Rayonier Performance Fibers Jesup Mill	Jesup, GA	14,700	41,200	7.1%
Georgia Pacific Cedar Springs LLC	Cedar Springs, GA	7,180	20,100	3.5%
All other Pulp and Paper Category mills reporting hydrogen sulfide releases (90 additional mills).		130,000	365,000	62.9%
<b>Total</b>		<b>207,000</b>	<b>580,000</b>	<b>100%</b>

Source: *TRILTOOutput2014\_v1*

Note: Sums of individual values may not equal the total presented, due to rounding.

#### **4.3.6 Pulp and Paper Category NPRI Analysis Introduction**

EPA evaluated the utility of using data from Canada’s NPRI to identify potential additional pollutants that may be present in industrial wastewater discharges from mills in the U.S., as indicated by their presence in industrial wastewater discharges from mills in Canada. Section 2.2 of this report provides a general overview of the NPRI analysis and methodology. This section presents EPA’s review of the NPRI data specific to the Pulp and Paper Category.

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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#### **4.3.6.1 NPRI Analysis Overview**

EPA compared water release data in TRI to data reported in Canada's NPRI for the Pulp and Paper Category to identify pollutants reported in NPRI, but not captured in the TRI. For those pollutants, EPA compared the reporting requirements between NPRI and TRI to understand the impact of any reporting differences (e.g., are the thresholds for reporting similar, do groups of reported chemicals include the same set of individual compounds, etc.) and further evaluated the potential for releases of these pollutants in the U.S.

For this analysis, EPA evaluated 2013 TRI and NPRI data, the most recent data available in both datasets at the time of review. EPA processed the data as described in Section 2.2 to obtain the relevant industry category, pollutant names, mill counts, and water releases for each of the datasets. For mills associated with the Pulp and Paper Category, EPA compared the list of pollutants with water releases reported to NPRI and TRI.

In 2013, 69 Canadian pulp and paper mills reported water release data for 41 pollutants to NPRI, while 226 U.S. pulp and paper mills reported water release data for 43 pollutants to TRI. As shown in Table 4-53, EPA identified 15 pollutants reported to NPRI that were not reported to TRI by pulp and paper mills in 2013. Six of the 15 pollutants are not included on the EPCRA Section 313 Chemical List for 2013 (2013 List of TRI Chemicals); therefore, facilities are not required to report releases for these pollutants (U.S. EPA, 2014c).

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-53. Pollutants Reported by Pulp and Paper Mills to 2013 NPRI but not to 2013 TRI**

Pollutant Name	On 2013 List of TRI Chemicals <sup>a</sup>	Number of NPRI Pulp and Paper Mills Reporting Pollutant Release to Water	Percentage of all NPRI Pulp and Paper Mills Reporting Water Release
Benzene	Y	2	3%
Benzo(e)pyrene	N	1	1%
Benzo(g,h,i)perylene	Y	1	1%
Cadmium (and its compounds)	Y	50	72%
Chlorine	Y <sup>b</sup>	3	4%
Chlorine dioxide	Y <sup>b</sup>	1	1%
Isopropyl alcohol	Y	1	1%
Methyl ethyl ketone	N <sup>c</sup>	5	7%
Methyl isobutyl ketone	Y	5	7%
Perylene	N	1	1%
Phenanthrene	Y	4	6%
Phosphorus (total)	N <sup>d</sup>	54	78%
Pyrene	N	8	12%
Selenium (and its compounds)	Y	23	33%
Total reduced sulfur (TRS)	N	17	25%

Sources: *NPRICompare2013*; *TRILTOOutput2013\_v1*; (U.S. EPA, 2014c).

- a Refers to pollutants included in the 2013 List of TRI Chemicals, regardless of whether water releases were actually reported for the pollutant.
- b Chlorine and chlorine dioxide are gaseous forms of chlorine, and not expected to be released to water under typical conditions (U.S. EPA, 1998).
- c Methyl ethyl ketone was removed from the List of TRI Chemicals in 2003 (U.S. EPA, 2015).
- d The 2013 List of TRI Chemicals only includes Phosphorus (yellow or white). Yellow and white phosphorus, both allotropes of elemental phosphorus, are hazardous pollutants that spontaneously ignite in air. During the 2006 Annual Review, EPA identified that mills were incorrectly reporting discharges of total phosphorus (i.e., the phosphorus portion of phosphorus-containing compounds) as phosphorus (yellow or white) (U.S. EPA, 2006b). Therefore, EPA concluded that it was appropriate to exclude all phosphorus (yellow or white) discharges reported to TRI, and has made such adjustments to the data, beginning with the 2011 Annual Review (U.S. EPA, 2012). Total phosphorous (as reported in NPRI) is not included in the current List of TRI chemicals (for reporting year 2015).

#### 4.3.6.2 NPRI Pollutant Analysis

EPA identified 15 pollutants reported to NPRI in 2013 that were not reported to TRI. EPA prioritized and further reviewed those pollutants reported by more than 20 percent of pulp and paper mills reporting water releases to NPRI. EPA performed a more in-depth analysis for the following pollutants:

- Cadmium and cadmium compounds (Cadmium)

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

- Total Phosphorus
- Selenium and selenium compounds (Selenium)
- Total reduced sulfur

### ***Review of Cadmium Discharges***

Cadmium is a TRI-listed pollutant; however, no U.S. pulp and paper mills reported cadmium releases in TRI in 2013. EPA evaluated the reporting requirements of the two programs and identified that the TRI reporting thresholds for cadmium are much higher than those of NPRI, which likely explains the discrepancy in the number of reporting mills between the two inventories. Both inventories base reporting thresholds on the amount of pollutant manufactured, processed, or otherwise used at the mill, not the amount discharged. In NPRI, cadmium is classified under Threshold Category 1B (alternate threshold substances), with a mass reporting threshold of 5 kilograms (kg) manufactured, processed, or otherwise used, and a concentration threshold of 0.1 percent by weight (Environment Canada, 2015). In TRI, the mass threshold is 25,000 pounds manufactured or processed, or 10,000 pounds otherwise used (U.S. EPA, 2014d).

EPA compared the magnitude of the cadmium releases reported in NPRI to available 2013 DMR data for cadmium. The 2013 NPRI cadmium releases ranged from 55 to 605 pounds per year for the top ten facilities reporting cadmium releases to NPRI (ranked by total pounds of cadmium released), as shown in Table 4-54. The cadmium discharges reported by the three pulp and paper mills with DMR discharges range from less than 1 to 50 pounds, as shown in Table 4-55. One mill accounts for 95 percent of the 2013 DMR cadmium discharges from pulp and paper mills. In general, the magnitude of cadmium releases in the 2013 NPRI is higher than the 2013 DMR cadmium loadings.

EPA considers it probable that no pulp and paper mills reported cadmium releases to TRI in 2013 because the reporting threshold was high (and higher than the NPRI reporting threshold).

**Table 4-54. Top 2013 Pulp and Paper Mills Reporting Cadmium Releases to NPRI**

<b>Mill Name</b>	<b>Mill Location</b>	<b>Pounds of Pollutant Released <sup>a</sup></b>
Edmundston Pulp Mill	Edmundston, NB	605
Neucel Specialty Cellulose (Sfo)	Port Alice, BC	179
Howe Sound Pulp And Paper Mill	Port Mellon, BC	133
Kamloops Mill (Sfo)	Kamloops, BC	120
Irving Pulp & Paper	Saint John, NB	108
Northwood Pulp Mill	Prince George, BC	105
Slave Lake Pulp - Slave Lake	Slave Lake, AB	95.0
Hinton Pulp	Hinton, AB	83.6
Thunder Bay Operations	Thunder Bay, ON	56.2
Papiers De Publication Kruger Inc. Usine De Trois-Rivières	Trois-Rivières, QC	55.6
All other Pulp and Paper Category mills reporting cadmium releases (40 additional mills)		875
<b>Total</b>		<b>2,420</b>

Source: (Environment Canada, 2014).

<sup>a</sup> All NPRI cadmium (and its compounds) releases were reported as direct releases.

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-55. Top 2013 Pulp and Paper Mills Reporting Cadmium Discharges on DMRs**

<b>Mill Name</b>	<b>Mill Location</b>	<b>Pounds of Pollutant Discharged</b>
Rocktenn - Fernandina Beach Mill	Fernandina Beach, FL	48.8
Meadwestvaco Custom Papers Laurel Mill	Lee, MA	1.47
Monadnock Paper Mills	Bennington, NH	0.59
<b>Total</b>		<b>51.1</b>

Source: *DMRLTOutput2013\_v1*.

As a next step to further understand cadmium discharges, EPA reviewed information from the 2006 detailed study. During the 2006 detailed study, EPA analyzed metals discharges, including discharges of cadmium, from pulp and paper mills. For the study, EPA collected information about the concentrations of metals in pulp and paper mill discharges from NPDES Permit Renewal Application (Form 2C) data and compared the concentrations to analytical method MLs. EPA concluded that cadmium concentrations were below the method MLs, and that intake concentrations of cadmium are generally similar to or higher than effluent concentrations (U.S. EPA, 2006a).

To further understand the sources, concentrations discharged, and wastewater treatment of cadmium in pulp and paper mill wastewaters, EPA contacted and reviewed additional information on this pollutant provided by the pulp and paper trade associations. Similar to the information provided for manganese, the pulp and paper trade associations compiled cadmium concentration data for pulp and paper mills from several data sources, including NCASI files, DMRs, Form 2C data, TRI, and NPRI. Section 4.3.4.3 presents the assumptions and limitations of the data compiled by the trade associations.

Table 4-56 presents the cadmium concentration data for pulp and paper mills compiled by the trade associations. Five out of eleven mills submitted zero or below detection limit cadmium concentrations on their 2014 DMRs. No pulp and paper mills reported cadmium releases to TRI in 2014<sup>33</sup> (NCASI, 2017). For comparison, Table 4-56 also presents the Method 200.7 ML for cadmium and ten times the ML. As shown, the median concentrations are below the ML (and below 10 times the ML). The maximum concentrations are all below 10 times the ML.

<sup>33</sup> EPA identified that the TRI reporting thresholds for cadmium are much higher than NPRI reporting thresholds for cadmium, which may explain the discrepancy in reporting rates.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-56. Comparison of Pulp and Paper Mill Cadmium Effluent Concentration Data from Trade Associations to the MDL**

Data Source	Reporting Year	Number of Mills	Cadmium Concentrations (µg/L)		
			Minimum	Median	Maximum
NCASI Data	1998	8	0.14	NA	1.70
DMR	2014	11	0 <sup>a</sup>	0.44	4.27
Form 2C	1997-2016	21	0.10	0.50	2.00
NPRI	2014	18	0.22	1.19	16.8
<b>Method 200.7 ML for Cadmium</b>			<b>2 µg/L</b>		
<b>10x Method 200.7 ML for Cadmium</b>			<b>20 µg/L</b>		

Source: (NCASI, 2017)

NA: Not applicable; trade associations did not provide the median concentration for the NCASI data source.

<sup>a</sup> Two mills reported zero values; no information was available regarding the detection limit for these mills. Three mills reported values below detection limits.

EPA also reviewed sources and treatment information provided by the pulp and paper trade associations. According to the trade associations, cadmium concentrations in mill discharges may result from (NCASI, 2017):

- Intake water
- Wood furnishes
- Processing additives (e.g., phosphoric acid, sulfuric acid, ammonia polyphosphate)
- Other raw materials used by the mill

The trade associations noted that two literature sources identified wood chips as accounting for 83.6 percent and 93.4 percent of the cadmium discharges in pulp and paper industry wastewater (NCASI, 2017).

Similar to the review of intake water for manganese concentrations discussed in Section 4.3.4.3, trade associations evaluated cadmium data from EPA’s WQX for a subset of mills. From this review, trade associations identified that median upstream ambient water cadmium concentrations were less than 0.25 µg/L. Trade associations noted that a focused study would be needed to make a definitive conclusion on whether intake water is a significant contributor to cadmium concentrations in mill effluent (NCASI, 2017). Upstream ambient manganese concentrations reported by the trade associations are lower than, but on the same order of magnitude as the median effluent concentration values shown in Table 4-56.

According to the pulp and paper trade associations, pulp and paper mills do not operate treatment technologies that specifically target removal of cadmium. However, cadmium may be incidentally removed through precipitation, adsorption, and biological uptake processes during primary or secondary treatment. From the review of industry literature, trade associations identified that municipal treatment plants with primary and secondary treatment generally remove more than 50 percent of cadmium from wastewater (NCASI, 2017). Trade associations identified that one mill collecting data between 1998 and 2002 achieved cadmium concentrations of less than 1 µg/L using aerated lagoon biological treatment, however, no removal efficiencies could be calculated. One trade association conducted bench-scale testing to evaluate whether

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

tertiary solids treatment for control of metals would increase cadmium removal from mill effluent. The technologies evaluated did remove more than 90 percent of cadmium spiked into a wastewater sample. However, no tests were conducted using native concentrations of cadmium (NCASI, 2017).

EPA also queried the IWTT Database for performance data on the treatment of cadmium, not specifically limiting its search to pulp and paper mills. Table 4-57 summarizes the identified treatment systems and their effectiveness. EPA did not identify any studies specifically citing cadmium removal in the pulp and paper industry. However, other industries, such as ore mining and dressing and metal finishing, remove metals using membrane filtration, secondary biological treatment, adsorptive media, and electrocoagulation. The reviewed studies reported cadmium effluent concentrations ranging from 0.85 µg/L to 130 µg/L, and removal efficiencies ranging from 71.2 percent to 99.9 percent. The median concentrations from the trade association effluent data (ranging from 0.44 µg/L and 1.19 µg/L) are on the lower end of the effluent concentration range identified from IWTT. Therefore, the studies do not demonstrate the availability of technologies that can reduce cadmium concentrations to below levels currently measured in pulp and paper mill discharges.

**Table 4-57. Summary of Wastewater Treatment Technologies for Cadmium**

Wastewater Treatment Technology (Order of Unit Processes)	Effluent Cadmium Concentration (µg/L) <sup>a</sup>	Percent Removal	Industry	Treatment Scale	Reference
Chemical Precipitation, Dissolved Air Flotation, Granular-Media Filtration	0.85	99.8%	Ore mining and dressing	Pilot	(Colic & Hogan, 2012)
Membrane Bioreactor, Aeration	2.4	98.1%		Pilot	(Progress, et al., 2012)
Electrocoagulation	NR	75%	Metal finishing	Pilot	(Firouzi, et al., 2009a)
	28	78.5%			(Firouzi, et al., 2009b)
	12	98.1%			
	130	97.2%			
	NR	99.9%			
Electrocoagulation, Membrane Filtration	4	98.6%		Pilot	(Ahmad, et al., 2010)
Aerobic Fixed Film Biological Treatment, Chemical Precipitation, Powdered Activated Carbon	< 1	NR			

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-57. Summary of Wastewater Treatment Technologies for Cadmium**

<b>Wastewater Treatment Technology (Order of Unit Processes)</b>	<b>Effluent Cadmium Concentration (µg/L) <sup>a</sup></b>	<b>Percent Removal</b>	<b>Industry</b>	<b>Treatment Scale</b>	<b>Reference</b>
Bag & Cartridge Filtration, Oil/Water Separation, Flow Equalization, Membrane Filtration	< 2	NR		Pilot	(Pugh, et al., 2014)
Mechanical Pre-Treatment, Flow Equalization, Oil/Water Separation, Membrane Bioreactor, Adsorptive Media	< 3	> 71.2%	Transportation equipment cleaning	Full	(Buckles, et al., 2007)

<sup>a</sup> Some studies reported effluent concentration data in mg/L. EPA converted the data to µg/L to facilitate comparison with mill effluent cadmium concentrations.

NR – Not Reported

### ***Review of Total Phosphorus Discharges***

No pulp and paper mills reported total phosphorus releases to TRI in 2013. However, TRI does include one form of phosphorus on the 2013 List of TRI Chemicals, known as yellow or white phosphorus (U.S. EPA, 2014c). Historically, as part of its annual review process EPA excludes yellow or white phosphorus reported to TRI from its analyses because this elemental form of phosphorus is insoluble in water and is not the same form of phosphorus commonly measured in wastewater (U.S. EPA, 2012). According to NPRI reporting guidance, total phosphorus does not include yellow or white phosphorus; NPRI includes yellow or white phosphorus as a separate pollutant (Environment Canada, 2015).

EPA compared the magnitude of the total phosphorus releases reported to NPRI to available 2013 DMR data for total phosphorus. The 2013 NPRI total phosphorus releases ranged from 67,900 to 323,000 pounds per year, as shown in Table 4-58, and the 2013 DMR total phosphorus discharges ranged from 53,600 to 215,000 pounds, as shown in Table 4-59, for the top ten facilities reporting total phosphorus releases to NPRI or DMR, respectively (ranked by total pounds of total phosphorus released). These top ten mills account for approximately 70 percent of the total 2013 DMR total phosphorus discharges reported by pulp and paper mills. In general, the magnitude of total phosphorus releases in the 2013 NPRI is similar to the 2013 DMR total phosphorus loadings.

Though several mills report total phosphorous discharges on DMRs, phosphorus does not have limitations under the Pulp and Paper ELGs. In addition, EPA has not previously reviewed total phosphorous discharges for the pulp and paper industry as part of recent annual reviews. Total phosphorous does not have an associated toxic weighting factor and subsequently does not appear in EPA’s TRA. See Section 2 of EPA’s 2015 Annual Review Report for more information on toxic weighting factors and EPA’s TRA (U.S. EPA, 2016a).

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-58. Top 2013 Pulp and Paper Mills Reporting Total Phosphorus Releases to NPRI**

Mill Name	Mill Location	Direct Pounds of Pollutant Released	Indirect Pounds of Pollutant Released	Total Pounds of Pollutant Released
Edmundston Pulp Mill	Edmundston, NB	323,000	0	323,000
Thunder Bay Operations	Thunder Bay, ON	97,500	0	97,500
Dryden Mill	Dryden, ON	96,900	0	96,900
Alberta-Pacific Forest Industries Inc.	County of Athabasca, AB	88,700	0	88,700
Kamloops Mill (Sfo)	Kamloops, BC	88,100	0	88,100
Corner Brook Pulp And Paper	Corner Brook, NL	81,700	0	81,700
Northwood Pulp Mill	Prince George, BC	78,400	0	78,400
Neucel Specialty Cellulose (Sfo)	Port Alice, BC	73,900	0	73,900
Prince George Pulp and Paper and Intercontinental Pulp Mills	Prince George, BC	69,500	0	69,500
Mackenzie Pulp Mill	MacKenzie, BC	67,900	0	67,900
All other Pulp and Paper Category mills reporting total phosphorus releases (44 additional mills)		1,050,000	15,800	1,070,000
<b>Total</b>		<b>2,120,000</b>	<b>15,800</b>	<b>2,130,000</b>

Source: (Environment Canada, 2014).

Note: Mills report pounds of pollutant released directly to surface waters or indirectly to POTWs.

**Table 4-59. Top 2013 Pulp and Paper Mills Reporting Total Phosphorus Discharges on DMRs**

Mill Name	Mill Location	Pounds of Pollutant Discharged
Georgia-Pacific - Crossett Plywood/Studmill Complex	Crossett, AR	215,000
Clearwater Paper Corp.	Lewiston, ID	191,000
Boise White Paper, LLC	International Falls, MN	121,000
International Paper-Eastover Mill	Eastover, SC	104,000
International Paper Franklin Mill	Franklin, VA	104,000
International Paper Company	Riegelwood, NC	92,400
Packaging Corp. of America	Tomahawk, WI	80,500
Blue Ridge Paper Products, Inc. (dba Evergreen Packaging)	Canton, NC	61,000
Resolute Forest Products Catawba Operations	Catawba, SC	57,500
Domtar Paper Company, LLC	Plymouth, NC	53,600
All other Pulp and Paper Category mills reporting total phosphorus releases (59 additional mills)		490,000
<b>Total</b>		<b>1,570,000</b>

Source: DMRLTOutput2013\_v1

To further understand the sources and treatment of total phosphorus in pulp and paper mill wastewaters, EPA contacted and reviewed additional information on this pollutant provided by the pulp and paper trade associations. According to the trade associations, pulp and paper mill

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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process wastewaters are generally nutrient deficient relative to what is needed for effective biological treatment. Therefore, mills often add supplemental forms of phosphorus to ensure effective biological treatment. Mills optimize supplemental addition of phosphorus to minimize residuals in effluent, but optimization strategies are dependent on several factors, including treatment type and configuration, and other effluent quality targets such as BOD and TSS. Phosphorus may also enter process wastewater through raw materials, intake water, and some process additives such as bleaching chemicals and defoamers (NCASI, 2016).

According to the trade associations, few pulp and paper mills operate treatment systems for removing residual nutrients from biologically treated effluents due to the prohibitive cost of these systems. Pulp and paper mills with low phosphorus permit limits generally operate activated sludge treatment (AST) for biological treatment minimization in conjunction with one or more of the following technologies: equalization or stabilization basin; tertiary flotation, mechanical clarification, or filtration; and chemical precipitation. Activated sludge basins (ASBs) are an alternative biological treatment method, however they are less efficient at phosphorus removal than AST. Other emerging nutrient treatment methods available to pulp and paper mills include chemical phosphorus removal, a biofilm activated sludge (BAS) process (consisting of a moving-bed biofilm reactor followed by an AST), AST with nitrogen fixation, chemical precipitation with enhanced solids removal, and constructed wetlands treatment (NCASI, 2016).

### ***Review of Selenium Discharges***

Selenium is a TRI-listed pollutant; however, no U.S. pulp and paper mills reported selenium releases in TRI in 2013. EPA evaluated the reporting requirements between the two programs and identified that the TRI reporting thresholds for selenium are much higher than those of NPRI, which likely explains the discrepancy in the number of reporting mills between the two inventories. Both inventories base reporting thresholds on the amount manufactured, processed, or otherwise used at the mill, not the amount discharged. In NPRI, selenium is classified under Threshold Category 1B (alternate threshold substances) with a mass reporting threshold of 100 kg manufactured, processed, or otherwise used, and a concentration threshold of 0.000005 percent by weight (Environment Canada, 2015). In TRI, the mass threshold is 25,000 pounds manufactured or processed or 10,000 pounds otherwise used (U.S. EPA, 2014d).

EPA compared the magnitude of the selenium releases reported in NPRI to available 2013 DMR data for selenium. The 2013 NPRI selenium releases ranged from 20 to 285 pounds per year for the top ten facilities reporting selenium releases to NPRI (ranked by total pounds of selenium released), as shown in Table 4-60. The selenium discharges reported by the two pulp and paper mills with DMR discharges are both less than one pound, as shown in Table 4-61. In general, the magnitude of selenium releases in the 2013 NPRI is higher than the 2013 DMR selenium loadings.

EPA considers it probable that no pulp and paper mills reported selenium releases to TRI in 2013 because the reporting threshold was high (and higher than the NPRI reporting threshold).

*4—EPA's Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-60. Top 2013 Pulp and Paper Mills Reporting Selenium Releases to NPRI**

Mill Name	Mill Location	Pounds of Pollutant Released <sup>a</sup>
AV Terrace Bay	Terrace Bay, ON	285
Harmac Pacific Operations	Nanaimo, BC	236
Neucel Specialty Cellulose (Sfo)	Port Alice, BC	158
Northwood Pulp Mill	Prince George, BC	127
Dryden Mill	Dryden, ON	111
Edmundston Pulp Mill	Edmundston, NB	108
Usine De Brompton, Sherbrooke	Sherbrooke, QC	45.2
Usine Laurentide	Grand-Mère, QC	29.5
Kapuskasing Operations	Kapuskasing, ON	27.7
Papiers De Publication Kruger Inc. Usine De Trois-Rivières	Trois-Rivières, QC	23.8
All other Pulp and Paper Category mills reporting selenium releases (13 additional mills)		88.3
<b>Total</b>		<b>1,240</b>

Source: (Environment Canada, 2014).

<sup>a</sup> All NPRI selenium releases were reported as direct releases.

**Table 4-61. Top 2013 Pulp and Paper Mills Reporting Selenium Discharges on DMRs**

Mill Name	Mill Location	Pounds of Pollutant Discharged
Molded Pulp Mill ISW	Red Bluff, CA	0.55
Fibrex Recycling US Inc-Fairmont Div	Fairmont, WV	0.404
<b>Total</b>		<b>0.954</b>

Source: DMRLTOutput2013\_v1

EPA did not analyze discharges of selenium as part of the 2006 detailed study because selenium was not among the ten pollutants with the highest TWPE, based on the 2002 DMR and TRI data (U.S. EPA, 2006a). Therefore, to further understand the sources, concentrations discharged, and treatment of selenium in pulp and paper mill wastewaters, EPA contacted and reviewed additional information on this pollutant provided by the pulp and paper trade associations. Similar to the information provided for manganese and cadmium, the pulp and paper trade associations compiled selenium concentration data for pulp and paper mills from several data sources, including NCASI files, DMRs, Form 2C data, TRI, and NPRI. Section 4.3.4.3 presents the assumptions and limitations of the data compiled by the trade associations.

Table 4-62 presents the selenium concentration data from pulp and paper mills compiled by trade associations. Two out of three mills submitted below detection limit selenium concentrations on their 2014 DMRs. No pulp and paper mills reported selenium releases to TRI in 2014<sup>34</sup> (NCASI, 2017). For comparison, Table 4-62 also presents the Method 200.7 ML for selenium and ten times the ML. As shown, all concentrations presented in the table are below the ML (and below 10 times the ML).

<sup>34</sup> EPA identified that the TRI reporting thresholds for selenium are much higher than NPRI reporting thresholds for selenium, which may explain the discrepancy in reporting rates.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-62. Comparison of Pulp and Paper Mill Selenium Effluent Concentration Data from Trade Associations to the MDL**

Data Source	Reporting Year	Number of Mills	Selenium Concentrations (µg/L)		
			Minimum	Median	Maximum
NCASI Data	1998	9	BDL	NA	6.6
DMR	2014	3	BDL	NA	4.72
Form 2C	1997-2016	8	1.2	3.2	37.0
NPRI	2014	11	0.22	1.49	3.90
<b>Method 200.7 ML for Selenium</b>			<b>50 µg/L</b>		
<b>10x Method 200.7 ML for Selenium</b>			<b>500 µg/L</b>		

Source: (NCASI, 2017)

NA: Not applicable; trade associations did not provide these data.

BDL: Below detection limit

EPA also reviewed sources and treatment information provided by the pulp and paper trade associations. According to the trade associations, selenium concentrations in mill discharges may result from (NCASI, 2017):

- Wood furnishes
- Processing additives (e.g., phosphoric acid, sulfuric acid)
- Other raw materials used by the mill

The trade associations reviewed data showing that selenium was detected in 10 of 26 wood furnish samples, at levels ranging from 30 µg/L to 240 µg/L. Selenium has been detected in process additives such as phosphoric acid and sulfuric acid (NCASI, 2017).

The trade associations also evaluated intake water for selenium from EPA’s WQX, similar to the intake water review for manganese and cadmium. From this review, trade associations identified that median upstream ambient water selenium concentrations were at or under the detection limit for all 117 measurements (NCASI, 2017). These data suggest that intake water is not a source of selenium in mill effluent.

Trade associations conducted a literature review for selenium removal at pulp and paper mills and identified that biological treatment is a common option for selenium removal in the mining and petroleum industries. While pulp and paper mills do not operate treatment technologies that specifically target the removal of selenium, trade associations suggested that it may be incidentally removed during primary and secondary treatment through precipitation, adsorption, or biological processes (NCASI, 2017).

EPA also queried the IWTT Database for performance data on the treatment of selenium, not specifically limiting its search to pulp and paper mills. Table 4-63 summarizes the identified treatment systems and their effectiveness. EPA did not identify any studies specifically citing the selenium removal for the pulp and paper industry. However, other industries, such as coal mining and petroleum refining, remove metals using biological treatment, chemical precipitation, membrane filtration, ion exchange, and adsorptive media. The reviewed studies showed reported selenium effluent concentrations ranging from less than 0.9 µg/L to 88 µg/L, and removal efficiencies ranging from 62.6 percent to 99.4 percent. The median concentrations from the trade

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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association effluent data (ranging from 1.49 µg/L to 3.2 µg/L) are on the lower end of the effluent concentration range identified from IWTT. Therefore, the studies do not demonstrate the availability of technologies that can reduce selenium concentrations to below levels currently measured in pulp and paper mill discharges.

*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

**Table 4-63. Summary of Wastewater Treatment Technologies for Selenium**

Parameter	Wastewater Treatment Technology (Order of Unit Processes)	Effluent Selenium Concentration (µg/L) <sup>a</sup>	Percent Removal	Industry	Treatment Scale	Reference
Selenium	Bag & Cartridge Filtration, Oil/Water Separation, Flow Equalization, Membrane Filtration	< 5	NR	Metal finishing	Pilot	(Pugh, et al., 2014)
	Mechanical Pre-Treatment, Flow Equalization, Membrane Filtration	NR	99.4%	Nonferrous metals manufacturing	Pilot	(Kim, et al., 2013)
	Biological Activated Carbon Filters	NR	80%		Pilot	(Diels, et al., 2003)
	Constructed Wetlands	NR	85%	Steam electric power generating	Pilot	(Morrison, et al., 2011)
	Chemical Precipitation, Clarification	NR	70%	Petroleum refining	Pilot	(Mauro, et al., 2013)
	Chemical Precipitation	7.9	95%	Petroleum refining	Pilot	(Pulliam, et al., 2010)
Selenium, total	Chemical Precipitation, Dissolved Air Flotation, Membrane Filtration, Reverse Osmosis	6.2	85.6%	Oil and gas extraction	Pilot	(Mah, et al., 2011)
	Ion Exchange	< 1	> 86.3%	Coal mining	Pilot	(Martins, et al., 2012)
	Zero-Valent Iron	NR	85%		Full	(Coal Mac Inc., 2011)
	Anaerobic Fixed Film Biological Treatment, Constructed Wetlands	< 0.9	> 93.4%			(Munirathinam, et al., 2011)
	Anaerobic Fixed Film Biological Treatment, Membrane Filtration	11.6	72.2%		Pilot	(Webster, et al., 2012)
	Anaerobic Fixed Film Biological Treatment, Granular-Media Filtration	< 4.7	> 88.8%		Pilot	(Gay, et al., 2012)
	Anaerobic Fixed Film Biological Treatment, Moving Bed Bioreactor	84	76.6%		Pilot	(McCloskey & Jettinghoff, 2009)
	Chemical Precipitation, Ballasted Clarification	6.8	62.6%	Petroleum refining	Pilot	(Hayes & Sherwood, 2012)
	Adsorptive Media	9	70%		Full	(Andalib, et al., 2016)
	Chemical Precipitation, Clarification, Flow Equalization, Ion Exchange, Anaerobic Suspended Growth, Clarification	88	85.9%	Steam electric power generating	Full	

<sup>a</sup> Some studies reported effluent concentration data in mg/L. EPA converted the data to µg/L to facilitate comparison with mill effluent selenium concentrations.  
 NR – Not Reported

*4—EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3—Pulp, Paper, and Paperboard (40 CFR Part 430)*

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### ***Review of Total Reduced Sulfur Discharges***

Because total reduced sulfur (TRS) is not a TRI-listed pollutant, no U.S. pulp and paper mills reported TRS releases in the 2013 TRI. In NPRI, TRS is calculated as the sum of the following compounds expressed as hydrogen sulfide: hydrogen sulfide, carbon disulfide, carbonyl sulfide, dimethyl sulfide, methyl mercaptan, and dimethyl disulfide (Environment Canada, 2015). Both U.S. and Canadian pulp and paper mills reported hydrogen sulfide separately from TRS. The 2013 List of TRI Chemicals includes carbon disulfide and carbonyl sulfide; however, the U.S. pulp and paper mills did not report either of these pollutants to TRI in 2013. Dimethyl sulfide, methyl mercaptan, and dimethyl disulfide are not in the 2013 List of TRI Chemicals. EPA reviewed 2013 DMR data and did not identify discharges of carbon disulfide, carbonyl sulfide, dimethyl sulfide, methyl mercaptan, and dimethyl disulfide discharges from pulp and paper mills.

Effective for the 2014 reporting year, NPRI no longer requires reporting of TRS releases to surface water (Environment Canada, 2015). Environment Canada states that TRS reporting had been included due to concerns about releases to air, not water. NPRI continues to require reporting of releases to water of hydrogen sulfide, carbon disulfide, and carbonyl sulfide individually (as does TRI). NPRI no longer requires reporting of water releases of dimethyl sulfide, methyl mercaptan, and dimethyl disulfide.

EPA considered the components of TRS individually to evaluate the need for further review. Based on the changes made to NPRI reporting requirements, dimethyl sulfide, methyl mercaptan, and dimethyl disulfide are not a priority for this review as they are likely air release concerns, not water release concerns. Pulp and paper mills reported hydrogen sulfide releases to both NPRI and TRI. EPA is already investigating releases of hydrogen sulfide, as discussed in Section 4.3.5. While carbon disulfide and carbonyl sulfide are included in the 2013 List of TRI Chemicals, no pulp and paper mills reported releasing these chemicals in 2013, either to TRI or on DMRs. Therefore, the data do not suggest that total reduced sulfur discharges from pulp and paper mills in the U.S. are a concern.

### ***4.3.7 Summary of the Pulp & Paper Category Review***

From its evaluation of lead, mercury, manganese, and hydrogen sulfide discharges, EPA learned:

- **Lead.** Lead does not have limitations under the Pulp and Paper ELGs; however, EPA identified 175 mills with reported releases to TRI in 2014. The review of direct discharge concentration data on 2014 DMRs and provided by mills showed the median concentrations for both the DMR and TRI data are an order of magnitude below the 2006 Form 2C median concentration and Method 200.7 ML. The review of indirect discharge concentration data provided by the mills showed that all average concentrations fall below the Method 200.7 ML. Though not directly applicable to pulp and paper mill wastewater, EPA’s review of available treatment technology information in IWTT identified effluent concentrations of lead similar to the 2014 median effluent lead concentrations identified during this review and well below the Method 200.7 ML for lead. Consistent with information from the 2006 detailed study,

4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)

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these analyses suggest that lead is not generally present at a level that could be controlled by further treatment.

- Mercury.* Mercury does not have limitations under the Pulp and Paper ELGs; however, EPA identified 86 mills with reported releases to TRI in 2014. The review of direct discharge concentration data on 2014 DMRs and provided by mills, showed that the median concentrations for both the DMR and TRI data are two orders of magnitude below the 2006 Form 2C median concentration and Method 245.1 ML. The review of indirect discharge concentration data provided by the mills showed that two of three average concentrations are below the Method 245.1 ML and the third average concentration is the same order of magnitude as the Method 245.1 ML. Though not directly applicable to pulp and paper mill wastewater, EPA’s review of available treatment technology information in IWTT identified that effluent concentrations of mercury are similar to the 2014 median effluent mercury concentrations identified during this review. Consistent with information from the 2006 detailed study, these analyses suggest that mercury is not generally present at a level that could be controlled by further treatment. Further, as shown in Table 4-39, several of the mills that provided data for this review indicate that they have put in place measures to monitor and control their sources of mercury.
- Manganese.* Manganese does not have limitations under Pulp and Paper ELGs; however, EPA identified 110 mills with reported releases to TRI in 2014. The median direct and indirect discharge concentrations, including the additional concentration data provided by the trade associations, are generally two orders of magnitude or more above the Method 200.7 ML, but similar to the 2006 Form 2C median concentration. These data are consistent with information from the 2006 detailed study and suggest that manganese discharges may be generally present at a level that could be controlled by further treatment.

During the 2006 detailed study, EPA identified that manganese concentrations are frequently higher in mill intake than in mill effluent and that the cost of treatment technologies targeting manganese make such technologies infeasible. EPA’s review of information provided by trade associations showed that wood furnish, and coal and oil used for energy generation may be primary sources of manganese in effluent discharges. Intake water may also be a source of manganese, though upstream monitoring data from EPA’s WQX suggest intake concentrations are generally lower than the evaluated effluent concentrations. At least one mill that EPA contacted during the review (Georgia-Pacific Crossett) indicated that surface water is a large source of manganese.

Trade associations suggest that treatment technologies currently implemented by the industry do not specifically target removal of manganese but may incidentally remove manganese. Though not directly applicable to pulp and paper mill wastewater, EPA’s review of available treatment technology information in IWTT identified effluent concentrations of manganese similar to the 2014 median effluent manganese concentrations identified during this review. These data do not conclusively demonstrate that the available technologies can reliably reduce manganese concentrations to below levels currently measured in pulp and paper mill discharges.

4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)

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- *Hydrogen sulfide.* Hydrogen sulfide was added as a TRI reporting requirement in 2012. Due to the number of mills with hydrogen sulfide releases in TRI, lack of historical release data, and possible overestimation of hydrogen sulfide releases in TRI data due to the current sampling convention, EPA further reviewed releases of hydrogen sulfide. EPA’s discussions with pulp and paper trade associations indicate that sampling methods have not been updated. Additionally, pulp and paper mills identified errors in their 2014 hydrogen sulfide data reported to TRI and provided corrected data. These corrections decreased the hydrogen sulfide 2014 TRI TWPE from 1,230,000 to 580,000. These analyses suggest that the hydrogen sulfide releases reported to TRI are still likely to be overestimated. In response, the industry is working to refine the sampling methods that will improve the accuracy of hydrogen sulfide data reported to TRI in the future.

EPA’s review of Canada’s NPRI identified 15 pollutants that were reported to NPRI in 2013, but not to TRI. EPA focused its review on cadmium, selenium, total phosphorus, and total reduced sulfur, as these pollutants were reported by more than 20 percent of the pulp and paper mills that reported to NPRI in 2013.

- *Cadmium and selenium.* Large percentages of Canadian pulp and paper mills reported releases of cadmium and selenium in the 2013 NPRI data (72 percent and 33 percent, respectively). Cadmium and selenium are on the 2013 List of TRI Chemicals; however, no mills reported releases to TRI in 2013. EPA identified that the TRI reporting thresholds are higher than the NPRI reporting thresholds for these pollutants, and that the differences in reporting requirements may explain the difference in reporting rates. EPA also identified only three mills with cadmium discharges and two mills with selenium discharges reported on 2013 DMRs. Cadmium and selenium discharges reported on DMRs were generally lower than releases of these chemicals reported to NPRI.

From review of additional information provided from pulp and paper trade associations, the median cadmium and selenium concentrations provided by trade associations are below the respective Method 200.7 ML (and ten times the ML), and therefore, may not be present at levels substantial enough for further treatment. EPA’s review of information provided by trade associations suggests that wood chips may be primary sources of cadmium in effluent discharges and wood furnish, process additives such as phosphoric acid and sulfuric acid, and other raw materials used by the mills may all be possible sources of selenium in effluent discharges. Intake water may also be a source of cadmium, though upstream monitoring data from EPA’s WQX suggest that intake concentrations are generally lower than the evaluated effluent concentrations. Review of upstream monitoring data from EPA’s WQX did not yield any detectable concentrations of selenium, suggesting that intake water is not a source of selenium in pulp and paper mill effluent.

Additionally, trade associations suggest that treatment technologies currently implemented by the industry do not specifically target removal of cadmium or selenium, but that biological treatment may incidentally remove cadmium or selenium. EPA queried the IWTT Database and did not identify information for technologies that achieve cadmium or selenium concentrations below levels currently

4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)

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measured in pulp and paper mill wastewater discharges; however, the data were not specific to pulp and paper mills.

- *Total phosphorus.* Seventy-eight percent of Canadian pulp and paper mills with NPRI data reported releases of total phosphorous in 2013 NPRI data. EPA’s investigation identified that NPRI and TRI have different reporting requirements for the different types of phosphorus, and TRI does not require reporting of total phosphorus. EPA reviewed 2013 DMR data and identified that 45 percent of pulp and paper mills reporting any pollutant loadings reported total phosphorous loads greater than zero. EPA has not previously evaluated total phosphorous discharges from pulp and paper mills. In general, the magnitude of total phosphorus releases in the 2013 NPRI is similar to the 2013 DMR total phosphorus loadings. Additionally, trade associations confirmed that mills often add supplemental forms of phosphorus to nutrient deficient wastewaters to ensure effective biological treatment. Other sources of phosphorus in pulp and paper mill wastewaters include raw materials, intake water, and process additives. Pulp and paper mills may implement phosphorous residual minimization techniques, but few operate treatment systems for removing residual nutrients from biologically treated effluents.
- *Total reduced sulfur.* NPRI has revised its reporting requirements for TRS. Mills are no longer required to report TRS but are required to report water releases of some TRS components, including hydrogen sulfide, carbon disulfide, and carbonyl sulfide. EPA is already investigating hydrogen sulfide, as discussed in Section 4.3.5. EPA did not identify any pulp and paper mills with 2013 DMR carbon disulfide or carbonyl sulfide discharges.

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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
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4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis  
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*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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*4–EPA’s Continued Preliminary Review of Categories Identified From the 2015 Toxicity Ranking Analysis*  
*Section 4.3–Pulp, Paper, and Paperboard (40 CFR Part 430)*

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## 5. EPA'S REVIEW OF ADDITIONAL INDUSTRIAL CATEGORIES

During the 2015 Annual Review, EPA also initiated a review of two additional point source categories to address comments received from stakeholders regarding recent changes to these industries as well as potential new pollutant releases to the environment through industrial wastewater discharge: Battery Manufacturing (40 CFR Part 461) and Electrical and Electronic Components (40 CFR Part 469) (EPA-HQ-OW-2015-0665-0299). From the 2015 Annual Review, data indicated that both industries have undergone technology advancements since the promulgation of the respective effluent limitations guidelines and standards (ELGs). However, EPA did not yet identify sufficient information to evaluate how the industry changes impact production processes, wastewater discharge and treatment, or applicability of the existing ELGs (EPA-HQ-OW-2015-0665-0290).

EPA continued its review of these two categories. Specifically, EPA conducted targeted literature reviews, attended industry conferences, met with trade associations, contacted facilities, reviewed company websites, evaluated available industry economic data, reviewed permit information, and analyzed readily available data on current discharges. EPA aimed to:

- Understand the current scope of the industries, including what types of products are currently, or are planned to be, manufactured, and how the profiles of the industries have changed since the promulgation of the ELGs.
- Identify which manufacturers discharge wastewater, whether they discharge directly or indirectly, what types of products they produce, which products generate a wastewater discharge, and what pollutants are discharged.
- Assess how permit writers and facilities are applying the ELGs to direct and indirect dischargers.
- Evaluate current wastewater treatment technologies and management techniques used by industry for identified processes and pollutants, and their ability to further reduce pollutant discharges.

In addition, EPA reviewed miscellaneous food and beverage manufacturing sectors not currently regulated by national ELGs, to identify specific sectors that may require further review for the potential development of ELGs.

EPA documented the quality of the data supporting its review of these industrial categories and sectors, analyzed how the data could be used to characterize the industrial wastewater discharges, and prioritized the evaluations for further review. See Appendix A of this report for more information on data usability and the quality of the data sources supporting these reviews.

Sections 5.1 and 5.2 of this report provide details of EPA's continued review of Battery Manufacturing and Electrical and Electronic Components, respectively. Section 5.3 of this report provides details of EPA's review of the miscellaneous food and beverage manufacturing sectors.

## 5.1 Battery Manufacturing (40 CFR Part 461)

As a part of its 2015 Annual Review, EPA initiated a preliminary review of the Battery Manufacturing Point Source Category Effluent Limitations Guidelines and Standards (ELGs) in response to stakeholder concerns about potential pollutants in wastewater discharges during the manufacture of new, advanced types of battery technologies, including development of rechargeable vanadium redox batteries and production of rechargeable lithium-ion batteries (including electric vehicle batteries). Unsolicited comments from stakeholders originally expressed these concerns, as well as comments submitted to EPA in response to the *Final 2010 Effluent Guidelines Program Plan* (76 FR 66286) (U.S. EPA, 2013).

During the 2015 Annual Review, EPA reviewed these ELGs, collected information about the current status of U.S. battery manufacturing, and evaluated the applicability of the existing ELGs to advances in battery technologies to learn whether recent changes within the industry have resulted in new wastewater pollutant discharges not currently covered by the existing ELGs. The existing rule applies to any battery manufacturing facility that discharges a pollutant to waters of the U.S or to publicly owned treatment works (POTWs); the discharge requirements vary depending on the anode materials (e.g., cadmium, lead, etc.). The preliminary review indicated that battery technologies have greatly advanced since 1984 with the advent of rechargeable batteries, such as lithium-ion and vanadium redox. Stakeholders questioned whether the existing ELGs are applicable to the manufacture of some of these types of batteries because their anode materials might not be covered by any of the specific ELG subcategories. Further, rechargeable batteries are generally identified by the ions (in the electrolyte) travelling between electrodes. The anode materials may vary within the same common battery type. For example, lithium-ion batteries with different anode composition may be covered under different subparts, or not at all (U.S. EPA, 2016).

The 2015 Annual Review identified only limited information regarding the extent of U.S. manufacturing of advanced and emerging battery technologies. EPA identified one facility, a Tesla Motors plant in Nevada, which will be manufacturing lithium-ion batteries on a large scale. In addition, stakeholders expressed concern over potential growth in manufacturing of vanadium redox and electric vehicle batteries and the implications of such growth for wastewater management. While battery technologies are advancing, EPA identified no generally available information regarding the generation of wastewater discharges from the manufacture of these new battery technologies (U.S. EPA, 2016).

As part of the current review, EPA evaluated 2014 discharge monitoring reports (DMRs) and the Toxics Release Inventory (TRI), National Pollutant Discharge Elimination System (NPDES) permits, and company websites. EPA's purpose was to:

- More thoroughly understand the current and emerging U.S. battery manufacturing industry, including the types of batteries produced, and applicability of the ELGs to those battery types.
- Identify new battery technologies, focusing on the design of the batteries and their industrial and commercial applications.
- Evaluate emerging battery technology processes and wastewater generated by them.

*5—EPA’s Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

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EPA also conducted a literature review to supplement the information gathered from the 2014 DMR and TRI data, NPDES permits, and company website searches. EPA documented the quality of the data supporting its review of this industry, analyzed how the data could be used to characterize the industrial wastewater discharges, and prioritized the results for further review. See Appendix A of this report for more information on data usability and the quality of data sources supporting this review. In addition, Appendix B of this report provides a list of the keywords that EPA used for the literature review searches.

The following sections provide an overview of the Battery Manufacturing ELGs, an overview of the industry profile, and a review of battery manufacturing wastewater generation and discharge.

### ***5.1.1 Overview of Existing Battery Manufacturing ELGs***

The Battery Manufacturing ELGs (40 CFR Part 461) were promulgated in 1984. The rule defines “battery” as a modular electric power source where part or all of the fuel is contained within the unit and electric power is generated directly from a chemical reaction rather than indirectly through a heat cycle engine. A battery cell has three major components: anode, cathode, and electrolyte. In addition, there are mechanical and conducting parts, such as a case, separator, or contacts. Production of batteries includes the electrode manufacture of anodes and cathodes and associated ancillary operations to produce the battery (U.S. EPA, 1984a). The ELGs set limits for subcategories based on the anode material: cadmium, calcium, lead, lithium, magnesium, and zinc; with an additional subcategory for leclanché cells (zinc anode batteries with acid electrolyte). Table 5-1 presents the applicability of each subcategory in the Battery Manufacturing ELGs and the regulated pollutants. Limitations are production normalized by the weight of the anode material, cathode material, or the entire battery cell, depending on the subcategory and waste stream.

5—EPA's Review of Additional Industrial Categories  
Section 5.1—Battery Manufacturing (40 CFR Part 461)

**Table 5-1. Applicability and Regulated Pollutants for the Battery Manufacturing Category**

Subpart	Subcategory	Applicability	Cadmium	Chemical Oxygen Demand (COD)	Chromium	Cobalt	Copper	Cyanide	Iron	Lead	Manganese	Mercury	Nickel	Oil and Grease	pH	Silver	TSS	Zinc
A	Cadmium	Manufacture of cadmium anode batteries.	✓			✓							✓	✓	✓	✓	✓	✓
B	Calcium	Manufacture of calcium anode batteries.	Zero Discharge															
C	Lead	Manufacture of lead anode batteries.					✓		✓	✓				✓	✓		✓	
D	Leclanché	Manufacture of Leclanché type batteries (zinc anode batteries with acid electrolyte).									✓	✓		✓	✓		✓	✓
E	Lithium	Manufacture of lithium anode batteries.			✓				✓	✓					✓		✓	
F	Magnesium	Manufacture of magnesium anode batteries.		✓					✓	✓					✓	✓	✓	
G	Zinc	Manufacture of zinc anode batteries.			✓			✓			✓	✓	✓	✓	✓	✓	✓	✓

Source: 40 CFR Part 461

### 5.1.2 Battery Manufacturing Industry Profile

During the 2015 Annual Review, EPA learned that battery technologies have substantially changed since the promulgation of the Battery Manufacturing ELGs in 1984. To explicate these changes, EPA prepared a summary of the 1984 industry profile, a current profile of battery manufacturing industry, and a discussion of new battery technologies that represent the potential future of the battery manufacturing industry.

#### 5.1.2.1 1984 Industry Profile

As explained above, EPA subcategorized this industry category on the basis of anode material and electrolyte. At the time of the rulemaking, data showed that battery cells with common process operations frequently used the same anode material, and that facilities manufacturing batteries with a common anode material generated wastewater bearing the same major pollutants (U.S. EPA, 1984a).

Typical applications of the batteries studied as part of the rulemaking ranged from use in small electronics (e.g., flashlights, calculators) to automotive and special military operations. Research performed during the rulemaking led EPA to decide that the value of industry products was increasing significantly at the time, accompanied by shifts in battery applications, the emergence of new types of cells, and the phase-out of other battery types. In 1984, EPA predicted that research in batteries and the continuing changes in electronics and transportation would continue to lead to rapid changes in battery manufacturing. The 1984 profile showed that over half of the manufacturing plants in the U.S. were less than 20 years old. Some manufacturing plants purchased finished cell components and assembled final battery products, some only manufactured battery components, and some had fully integrated onsite production operations, including metal forming and inorganic chemicals manufacture (U.S. EPA, 1984a).

As part of the rulemaking, EPA collected information from 254 U.S. battery manufacturing facilities. At the time, 21 facilities reported having direct discharges to surface waters, 149 reported discharges to POTWs, and 84 reported zero discharges. Lead battery manufacturing facilities accounted for greater than 70 percent of all facilities and about 90 percent of process wastewater flow. Cadmium, leclanché, and zinc battery manufacturers together made up 20 percent of all facilities and 10 percent of process wastewater flow (U.S. EPA, 1984a, 1984b).

The 1984 industry profile showed that water was used throughout the battery manufacturing process to clean battery components and to transport wastes. Water was used in the chemical systems to make most electrodes and special electrode chemicals and was a major component of most electrolyte and formation baths. Based on sampling done for the 1984 rulemaking, EPA learned that the pollutants in battery manufacturing wastewater varied depending on the anode and included (U.S. EPA, 1984a):

- Toxic metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc).<sup>35</sup>

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<sup>35</sup> Arsenic and selenium are not regulated parameters under 40 CFR Part 461; however, arsenic and selenium were cited as verification parameters in the 1984 rulemaking for the leclanché and zinc subcategories (U.S. EPA, 1984a).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

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- Nonconventional pollutants (aluminum, cyanide, cobalt, iron, manganese, and chemical oxygen demand (COD)).<sup>36</sup>
- Conventional pollutants (oil and grease, total suspended solids (TSS), and pH).

The control and treatment technologies available for the battery industry at the time of the 1984 rulemaking included both in-process and end-of-pipe operations. The technology basis for the limitations and standards included a variety of water flow reduction steps and process changes (e.g., substitution of non-wastewater-generating forming systems). End-of-pipe treatment included hexavalent chromium reduction, chemical precipitation, settling/sedimentation, and filtration (U.S. EPA, 1984a).

### 5.1.2.2 Current Industry Profile

For the current review, EPA reviewed publicly available U.S. Economic Census data, 2014 DMRs, and the 2014 TRI to evaluate the current number of battery manufacturers in the U.S. and understand the nature of their industrial wastewater discharges. EPA first reviewed the North American Industry Classification System-Point Source Category (NAICS-PSC) and Standard Industrial Classification-Point Source Category (SIC-PSC) crosswalks developed for the 304m Annual Review process.<sup>37</sup> From this review, EPA identified two NAICS codes that correspond to facilities that are likely to fall under the Battery Manufacturing Category:<sup>38</sup>

- 335911 – Storage Battery Manufacturing
- 335912 – Primary Battery Manufacturing

A storage battery is a battery that can store chemical energy with the potential to change to electricity. The conversion of chemical energy to electricity can be reversed, thus allowing the battery to be recharged. Examples of storage batteries include automobile batteries, lead-acid batteries, and alkaline cell batteries (nickel-cadmium, nickel-iron, silver oxide-zinc). Primary batteries, in contrast, cannot usually be recharged and must be replaced after one discharge (U.S. EPA, 1984a). Examples of primary batteries include disposable flashlight batteries and watch batteries. Based on the 2012 U.S. Economic Census data, EPA identified 140 U.S. battery-manufacturing establishments,<sup>39</sup> the majority of which are in California, Missouri, Florida, Illinois, Massachusetts, and Michigan (ERG, 2016a). To identify potential trends in the industry, EPA compared the number of establishments reported in every U.S. Economic Census year from 1977 to 2012. Figure 5-1 presents the results of EPA's comparison. The number of battery

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<sup>36</sup> Aluminum is not a regulated parameter under 40 CFR part 461; however, was cited as a verification parameter in the 1984 rulemaking for the zinc subcategory (U.S. EPA, 1984a).

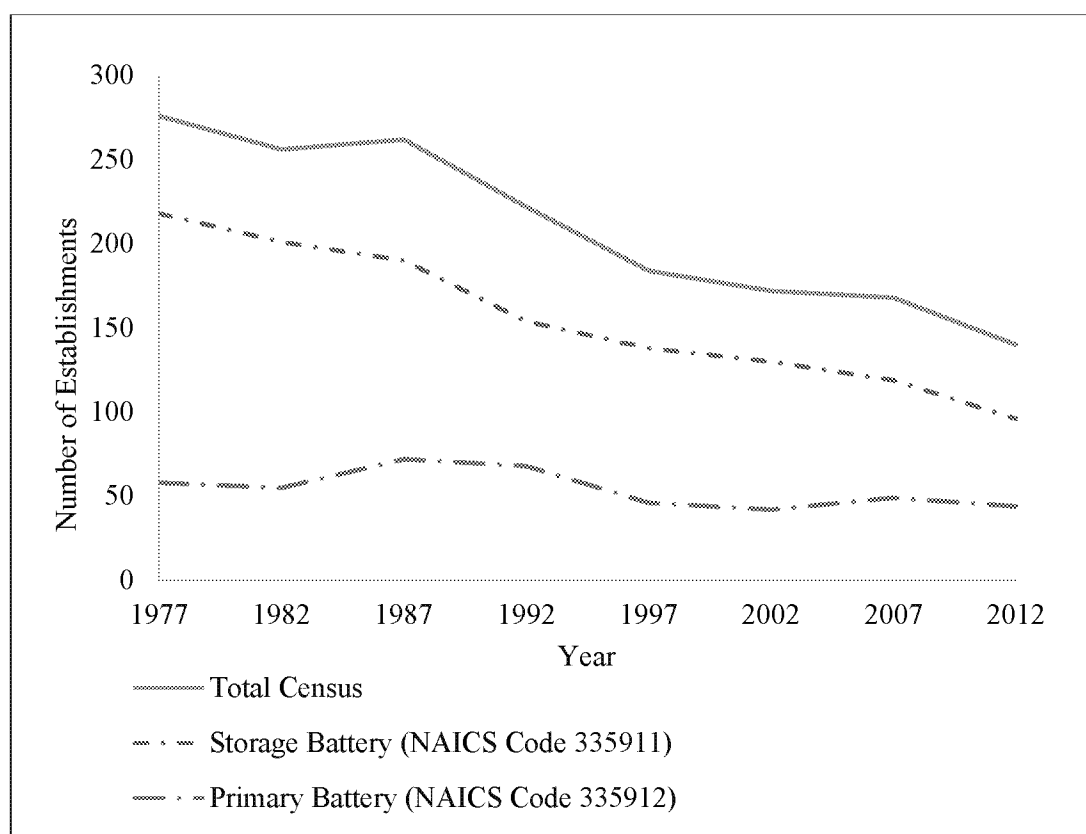
<sup>37</sup> For further information on the NAICS-PSC and SIC-PSC crosswalks, see the *Technical Support Document for the Annual Review of Existing Effluent Guidelines and Identification of Potential New Point Source Categories* (U.S. EPA, 2009).

<sup>38</sup> The corresponding SIC codes are: 3691 (Storage Batteries) and 3692 (Primary Batteries, Wet and Dry).

<sup>39</sup> Defined as a business or industrial unit at a single location that distributes goods or performs services. It is not necessarily identified with a company or enterprise, which may consist of one or more establishments. When two or more activities are carried on at a single location under a single ownership, all activities generally are grouped together as a single establishment. The entire establishment is classified on the basis of its major activity and all data are included in that classification (U.S. Census Bureau, 2016).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

manufacturing establishments for both NAICS codes, and the total battery manufacturing industry, declined from 1977 to 2012.



Source: (ERG, 2016a)

**Figure 5-1. Number of U.S. Battery Establishments from 1977 through 2012**

EPA also reviewed the total number of battery manufacturing facilities reporting 2014 DMR and TRI discharges greater than zero. As shown in Table 5-2, EPA identified 56 battery manufacturers reporting 2014 discharges, the majority of which are indirect dischargers. This is approximately one-third of the total number of battery manufacturing facilities identified as part of the 1984 rulemaking (21 direct dischargers and 149 indirect dischargers). While the DMR and TRI datasets provide the most comprehensive source of information on existing wastewater discharges in the U.S., this count may not represent the total number of battery manufacturer discharges in 2014, see Section 2.1 of this report for details on the utility and limitations of the DMR and TRI data.

EPA notes that the U.S. Economic Census data include more facilities than the 2014 DMR and TRI data. There are several potential reasons for this: some facilities may not meet TRI-reporting thresholds; some facilities may be classified as minor dischargers and therefore, may not be captured in the DMR data;<sup>40</sup> some facilities in the U.S. Economic Census data are

<sup>40</sup> Minor dischargers must report compliance with NPDES permit requirements via monthly DMRs submitted to the permitting authority; however, EPA does not require the permitting authority to enter the data in the Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES) which contains the DMR data.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

distributors or sales facilities, not manufacturers; and some battery manufacturers may not discharge wastewater and, therefore, may not report to DMR and/or TRI.

**Table 5-2. Number of Battery Manufacturing Facilities in the DMR and TRI Data**

Year of Discharge	Year of Review	2014 DMR Facilities <sup>a</sup>	2014 TRI Facilities		
			Direct Only	Indirect Only	Both Direct and Indirect
2014	2016	2	1	36	19

Sources: *DMRLTOutput2014\_v1* and *TRILTOutput2014\_v1*.

Note: Number of facilities with loadings greater than zero.

<sup>a</sup> Both 2014 DMR facilities are classified as minor dischargers.

For all 56 battery manufacturers reporting 2014 DMR and TRI discharges greater than zero, EPA reviewed company websites to identify the types of batteries currently being manufactured in the U.S. (ERG, 2016b).<sup>41</sup> Table 5-3 summarizes the battery types and the number of facilities manufacturing each type. As shown by the facility counts, several facilities manufacture more than one type of battery. From its review of the battery types, EPA also attempted to assign the applicable subcategory from the Battery Manufacturing ELGs.

**Table 5-3. Types of Batteries Manufactured in the U.S. Associated with 2014 Wastewater Discharges**

Battery Type	Count of Facilities	Applicable Subcategory(ies)
Alkaline	4	Zinc
Carbon-Zinc	1	Leclanché
Lead Carbon	1	May be Subject to Lead Subcategory
Lead-Acid	40	Lead
Lithium-ion	14	May be Subject to Lithium Subcategory
Nickel-cadmium	4	Cadmium
Nickel-hydrogen	1	May be Subject to Cadmium Category
Zinc Air	2	Leclanché, Zinc

Source: (ERG, 2016b).

This review indicates that the majority of battery manufacturers in the U.S. currently manufacture lead-acid and lithium-ion batteries.

<sup>41</sup> Both facilities reporting 2014 DMR discharges are also captured in the 2014 TRI counts; therefore, the total number of facilities is 56, not 58.

### 5.1.2.3 Potential Future Industry Trends

Though EPA's review of the U.S. Census data indicates an overall decline in the number of battery manufacturing facilities in the U.S. since the 1984 rulemaking, information gathered during the 2015 Annual Review indicates the potential emergence of new battery technologies into the market. To further EPA's understanding of future industry trends and in light of recent technology advances within the industry, EPA conducted a literature review, reviewed economic forecasts, and contacted battery manufacturers as part of this review. EPA's literature review focused on identifying emerging battery technologies and the manufacturers of these new batteries in the U.S. See Appendix B for the keyword searches done for the literature review.

From the literature review, EPA identified several lithium-ion battery manufacturers associated with the electric vehicle industry that are currently operating or planning to operate in the U.S. The literature suggests that the majority of these manufacturers are not operating at full capacity, as the electric vehicle industry is still developing (Bomgardner, 2012).

Economic forecasting data confirm that the battery manufacturing industry has declined over the past five years. The declining demand for battery manufacturing in the U.S. results largely from the introduction and use of rechargeable batteries in smart phones, tablets, and other electronics. The demand for batteries in the U.S. is further limited by the fact that the majority of these electronics are manufactured overseas in countries that produce and use their own respective batteries. However, the economic forecasting data also show that the battery manufacturing industry will grow slightly over the next five years, due to the demand for rechargeable batteries to power electric vehicles manufactured in the U.S. (IBISWorld, 2016).

### 5.1.2.4 Emerging Battery Technologies Review

EPA's literature review and search of company websites also identified several new battery technologies since the 1984 ELGs. In addition to rechargeable lithium-ion batteries, rechargeable nickel-hydrogen, nickel-metal hydride, and vanadium-redox flow batteries have been developed. Based on the initial review, EPA further investigated the battery components, current applications, and any information on the manufacture of these batteries in the U.S. The following subsections present information on these emerging battery technologies.

#### *Lithium-ion Batteries*

Lithium-ion batteries are rechargeable batteries in which lithium-ions move from the anode to the cathode during discharge and from the cathode to the anode during recharge. Lithium-ion battery technologies are rapidly advancing, and there are many battery types and configurations using a variety of materials for the anode, cathode, and electrolyte. In these batteries, lithium is not necessarily the anode material, but often part of the electrolyte, which can be a solid or liquid medium (Salkind, et al., 2003). Graphite or hard carbon is often used as the anode material, as well as lithium and lithium alloys. The industry is also developing lithium-ion batteries using silicon as the anode material (Patterson, 2009).

As shown in Table 5-3, EPA identified 14 facilities manufacturing lithium-ion batteries in the U.S. reporting wastewater discharges. Currently, the ELGs cover wastewater discharges from the manufacture of lithium-ion batteries that use lithium as the anode material (Subpart E,

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

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Lithium). This subpart does not cover manufacture of lithium-ion batteries using non-lithium anode materials.

Lithium-ion batteries are used in a variety of applications, including advanced start/stop vehicles, hybrid and electronic vehicles, aircraft, and other specialty applications (ERG, 2016b). In addition to the 14 facilities reporting discharges from lithium-ion battery manufacturing in 2014, EPA identified another U.S. facility, as part of the 2015 Annual Review, that began manufacturing lithium-ion (i.e., rechargeable) batteries in the U.S., the Tesla Motors Gigafactory in Nevada. EPA contacted Tesla for information about the Gigafactory, which began battery cell production on January 4, 2017, and is scheduled to reach full manufacturing capacity by 2018 (Tesla Motors, 2017). The Gigafactory will manufacture lithium-ion batteries for use in electronic vehicles and the Powerwall, a rechargeable lithium-ion battery designed to store energy at individual residences, to be used for load shifting, backup power, and self-consumption of solar power generation. Tesla indicated that the facility will not discharge any wastewater and that they anticipate that by 2020 this factory will produce more lithium-ion batteries annually than were produced worldwide in 2013 for electric vehicles and rechargeable homes (Jackson, 2016; Tesla Motors, 2015, 2017).

#### ***Nickel-Hydrogen Batteries***

Nickel-hydrogen batteries are rechargeable batteries with a solid nickel electrode and a negative platinum gas electrode. The negative platinum gas electrode contains catalyzed sites that allow for the electrochemical reaction of hydrogen gas. The cell case for this type of battery is a pressure vessel as the negative active material is hydrogen gas. Nickel-hydrogen batteries began replacing nickel-cadmium batteries after successful use on communication satellites in 1983. Because these batteries are primarily used in aerospace energy storage applications, NASA is the biggest researcher and producer (Thaller & Zimmerman, 2003).

As shown in Table 5-3, EPA identified one U.S. facility (Duracell, in LaGrange, GA) that may be manufacturing nickel-hydrogen batteries and reporting wastewater discharges in 2014. The facility reported releases totaling less than 1 pound of pollutants to a POTW. Based on EPA's review of nickel-hydrogen battery production and the Battery Manufacturing ELGs, wastewater discharges from the manufacture of nickel-hydrogen batteries are currently not subject to the ELGs.

#### ***Nickel-Metal Hydride Batteries***

Nickel-metal hydride batteries are rechargeable batteries with a nickel hydroxide cathode, misch metal hydride anode, a potassium hydroxide electrolyte, and a porous polypropylene membrane separator. These batteries have become popular and are replacing nickel-cadmium batteries in many applications, specifically in the hand-held power tools market, and are also used in hybrid electric vehicles. However, one source (Argonne National Laboratory (ANL), 2010) indicated that lithium-ion batteries are starting to replace nickel-metal hydride batteries, owing to superior specific energy and cycle life.

Ovonic Battery Corporation (currently known as BASF Corporation) invented nickel-metal hydride batteries. It is not known whether the BASF Corporation manufacturing facilities in the U.S. are currently manufacturing nickel-metal hydride batteries (BASF, 2016). As shown

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

in Table 5-3, EPA did not identify any U.S. battery manufacturing facilities reporting 2014 DMR or TRI discharges associated with the manufacture of nickel-metal hydride batteries. Based on EPA's review of nickel-metal hydride battery production and the Battery Manufacturing ELGs, wastewater discharges from the manufacture of nickel-metal hydride batteries are currently not subject to the ELGs.

### ***Vanadium Redox Flow Batteries***

EPA's research indicates that vanadium redox, or vanadium flow, batteries are being developed to function as sources of energy during power outages and for use in remote areas and developing countries. These batteries are rechargeable and generate electricity by pumping liquid electrolytes containing vanadium ions through electrochemical cells separated by ion selective membranes (Salkind, et al., 2003). Unlike traditional batteries, flow batteries are not closed systems. This allows for potential replacement of depleted electrolyte and may result in a reduced rate of degradation of the anode and cathode materials (St. John, 2014). Flow batteries contain a liquid electrolyte; therefore, handling may be a concern for disposal or waste management.

Available information suggests that vanadium redox battery manufacturing in the U.S. is currently limited to the research and development phase. Graphite, which is not an anode material subject to the current ELGs, is a commonly used anode material in vanadium flow batteries (U.S. EPA, 2016).

#### **5.1.2.5 Evaluation of Current Wastewater Discharges**

In order to further review the battery manufacturing industry and understand current wastewater discharges, EPA evaluated the 2014 DMR and TRI data for the 56 facilities reporting discharges. Table 5-4 and Table 5-5 provide a summary of the pollutant discharges across the facilities for the 2014 DMR and TRI data, respectively. The pollutants are ordered based on toxic-weighted pound equivalents (TWPE) discharged, calculated by assigning a relative toxic weighting factor to the estimated loads from each facility.<sup>42</sup>

**Table 5-4. Battery Manufacturing Category: Pollutants Reported on 2014 DMRs**

<b>Pollutant</b>	<b>Number of Facilities Reporting Pollutant</b>	<b>Pollutant Load (lb/yr)</b>	<b>TWPE</b>
Lead	2	56.5	126
Copper	1	0.830	0.517
Iron	1	8.06	0.0452
Chemical Oxygen Demand (COD)	1	9,190	0
Total Suspended Solids (TSS)	2	7,350	0
Oil and Grease	1	3,600	0
<b>Battery Manufacturing Total</b>	<b>2</b>	<b>20,200</b>	<b>127</b>

Source: *DMRLTOutput2014\_v1*

Note: Sums of individual values may not equal the total presented, due to rounding.

<sup>42</sup> See Section 2 of EPA's 2015 Annual Review Report for more information on how EPA applies toxic weighting factors to facility discharges in the DMR and TRI data (U.S. EPA, 2016).

5—EPA's Review of Additional Industrial Categories  
Section 5.1—Battery Manufacturing (40 CFR Part 461)

**Table 5-5. Battery Manufacturing Category: 2014 Pollutants Reported to TRI**

Chemical Name	Number of Facilities Reporting Pollutant	Direct Discharge Pollutant Load (lb/yr)	Direct Discharge TWPE	Indirect Discharge Pollutant Load (lb/yr)	Indirect Discharge TWPE	Total Pollutant Load (lb/yr)	Total Pollutant TWPE
Lead and Lead Compounds	45	353	791	64.2	144	417	935
Sodium Dimethyldithiocarbamate	1	0	0	1,680	134	1,680	134
Cadmium and Cadmium Compounds	3	1.20	27.4	0.111	2.54	1.31	29.9
Nitrate Compounds	1	0	0	33,600	25.1	33,600	25.1
Manganese and Manganese Compounds	5	120	12.4	15.6	1.61	136	14.0
Copper and Copper Compounds	4	7	4.36	0.387	0.241	7.39	4.60
Nickel and Nickel Compounds	6	17.1	1.71	27.4	2.74	44.5	4.45
Zinc and Zinc Compounds	5	37	1.48	11.8	0.470	48.8	1.95
Cobalt and Cobalt Compounds	2	0	0	1.53	0.168	1.53	0.168
Antimony and Antimony Compounds	8	4.65	0.0465	1.09	0.0109	5.74	0.0574
Arsenic and Arsenic Compounds	2	0	0	0.0117	0.0404	0.0117	0.0404
Mercury and Mercury Compounds	2	0	0	0.000204	0.0224	0.000204	0.0224
Silver and Silver Compounds	1	0	0	0.00036	0.00593	0.00036	0.00593
Barium and Barium Compounds	1	2.74	0.00545	0	0	2.74	0.00545
Lithium Carbonate	1	0	0	0.99	0	0.99	0
N-Methyl-2-Pyrrolidone (NMP)	1	0	0	1,220	0	1,220	0
<b>Total</b>	<b>56</b>	<b>543</b>	<b>838</b>	<b>36,700</b>	<b>311</b>	<b>37,200</b>	<b>1,150</b>

Source: TRIOutput2014\_v1.

Note: Sums of individual values may not equal the total presented, due to rounding.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

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EPA compared the pollutants listed in Table 5-4 and Table 5-5 to the pollutants currently regulated by the ELGs (shown in Table 5-1). EPA learned that five of the six pollutants reported by the two DMR facilities are subject to limitations in the current ELGs for the lead subcategory as both facilities manufacture lead-acid batteries (the lead subcategory does not regulate COD). Out of the 16 pollutants reported in the 2014 TRI, seven are not currently subject to limitations in the ELGs, however, EPA recognizes that the seven pollutants may be controlled by the technology basis for the regulated pollutants in the applicable subcategory. These seven pollutants are:

- Sodium dimethyldithiocarbamate
- Nitrate compounds
- Antimony and antimony compounds
- Arsenic and arsenic compounds
- Barium and barium compounds
- Lithium carbonate
- N-Methyl-2-Pyrrolidone (NMP)

During the 1984 rulemaking, EPA reviewed antimony and arsenic discharges and did not identify them as pollutants of concern. As shown in Table 5-5 above, collective 2014 reported discharges of the two pollutants for this industry are about six pounds annually. The remaining five pollutants are not reported by more than one facility. Further, only the barium and barium compound releases are based on actual monitoring data; the rest of the TRI releases are estimated from calculations such as published emission factors, mass balance calculations, or other engineering calculations that can be used to estimate TRI releases.

Additionally, EPA attempted to find and review permit documentation for all 56 facilities reporting 2014 DMR discharges or 2014 TRI direct discharges. EPA was able to locate and review a total of seven NPDES permits to identify wastewater discharges associated with battery manufacturing processes.

As shown in Table 5-4, EPA identified only two facilities reporting discharges greater than zero in 2014 DMRs. Based on website searches described above, EPA learned that these two facilities manufacture lead-acid batteries (ERG, 2016b). One facility, Exide Technologies in Manchester, Iowa, has permit limits for process wastewater resulting from the production of lead-acid batteries for copper, lead, iron, oil and grease, and total suspended solids. These permit limits are based on water quality criteria and the current ELGs. The treatment at the facility includes chemical precipitation and clarification (IA DNR, 2014). The other facility, C&D Technologies in Attica, Indiana, is only authorized to discharge stormwater, not process wastewater from the manufacture of lead-acid batteries (IDEM, 2014).

EPA was able to obtain and review five additional NPDES permits for battery manufacturers identified as direct dischargers in the 2014 TRI.<sup>43</sup> Based on the company website and NPDES permit review, EPA learned that four of these facilities manufacture lead-acid

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<sup>43</sup> Although these five facilities reported direct releases to the 2014 TRI, they may not be captured in the 2014 DMR data if they are minor dischargers, as some states do not upload DMRs for minor facilities.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.1—Battery Manufacturing (40 CFR Part 461)*

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batteries and are only authorized to discharge stormwater. The remaining permit limits discharges of non-contact cooling water and cooling tower blowdown from a facility that manufactures both lead-acid and lithium-ion batteries (ERG, 2016b).

To supplement discharge information obtained from its review of 2014 DMR, TRI, and NPDES permits, EPA also conducted a literature review of the production processes and wastewater generation from some of the emerging U.S. battery technologies. EPA focused this review on lithium-ion batteries because of the potential applicability considerations and the number of facilities reporting wastewater discharges associated with lithium-ion battery manufacturing in 2014 (see Table 5-3). EPA did not include a review of lead-acid batteries because they are subject to the current ELGs. EPA also did not include nickel-cadmium batteries because they are being phased out of production (i.e., replaced with nickel-metal hydride and other technologies), or nickel-metal hydride and vanadium redox batteries because they were not identified as being manufactured in the U.S. on a large scale.

The basic production steps for lithium-ion batteries include the following (Argonne National Laboratory (ANL), 2010):

- Preparation of the cathode pastes and cathodes from purchased lithium metal oxides, binders, aluminum strips, and solvent.
- Preparation of anodes from graphics pastes and copper strips.
- Assembly of anodes and cathodes, separated by a separator strip.
- Addition of the electrolyte.
- Charging of the cells.
- Final assembly.

The literature review revealed that electrolyte processing, paste production, separator production, and formation/testing (i.e., final assembly) may generate wastewater during the manufacture of lithium-ion batteries. However, manufacturers may use either dry or wet processes for these production steps. Research suggests the industry is trending toward dry processes. For example, the industry developed dry electrode manufacturing, a process that eliminates the need for solvents in electrode processing and paste production steps, in 2016. While this process is still being researched, it may become the new industry standard given the environmental concerns surrounding NMP, a non-aqueous solvent traditionally used for electrode processing and paste production in lithium-ion battery production (Ludwig, et al., 2016).

EPA also attended a conference and spoke with several battery manufacturers to gather additional information on processes and wastewater discharges from battery manufacturing. EPA confirmed that there is little water used and/or generated in battery manufacturing processes (e.g., water for charging baths, cooling systems, electrolyte solutions, washing/cleaning processes) (ERG, 2016c). This information is consistent with information obtained from Tesla, which will be operating the Gigafactory in Nevada as a zero discharge facility (Jackson, 2016).

### 5.1.2.6 Summary of Evaluations from EPA's Review of Battery Manufacturing

EPA's research indicates that some battery technologies have changed since the promulgation of the Battery Manufacturing ELGs in 1984, with the advent of rechargeable batteries, including lithium-ion, nickel-hydrogen, nickel-metal hydride, and vanadium redox batteries. The ELGs apply to discharges from the manufacturer of batteries with specific anode materials (e.g., cadmium, lead, zinc). Some of the new battery technologies (i.e., lithium-ion) may not be covered under any of these specific ELG subcategories due to the variety of materials that can now be used for anodes. In addition, it is not clear that the existing ELGs cover or are applicable to several new battery technologies (e.g., lead carbon and nickel-hydrogen).

In its review of the battery manufacturing industry, EPA did not identify any uncontrolled pollutants that represent a category-wide issue. Further, the manufacture of emerging battery technologies in the U.S. is trending toward zero discharge and EPA identified few discharges that are not subject to the current ELGs. This is most notably demonstrated by the Tesla Gigafactory, which is expected to be the world's largest producer of lithium-ion batteries and will operate as a zero discharge facility (Jackson, 2016).

### 5.1.3 References for Battery Manufacturing (40 CFR Part 461)

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5—EPA's Review of Additional Industrial Categories  
Section 5.1—Battery Manufacturing (40 CFR Part 461)

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*5–EPA's Review of Additional Industrial Categories*  
*Section 5.1–Battery Manufacturing (40 CFR Part 461)*

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*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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## **5.2 Electrical and Electronic Components (E&EC) (40 CFR Part 469)**

As part of the 2015 Annual Review, EPA initiated a preliminary review of the Electronics and Electrical Components (E&EC) Category in response to stakeholder comments received during a 2014 National Association of Clean Water Agencies (NACWA) conference regarding the applicability of the effluent limitations guidelines and standards (ELGs) to the manufacture of sapphire crystals. Stakeholders expressed concerns about potential new pollutants of concern in the wastewater discharges from the manufacture of sapphire crystals (now commonly used in electronic devices), which they believe EPA did not consider during the development of the E&EC ELGs.

While the E&EC ELGs do not specifically mention sapphire crystals, from the 2015 Annual Review EPA identified that Subpart B - Electronic Crystals covers wastewater discharges generated from growing sapphire crystals and producing sapphire crystal wafers. Sapphire crystals are a crystal or crystalline material used in the manufacture of electronic devices because of their unique structural and electronic properties, and therefore, meet the applicability of Subpart B. Additionally, sapphire-crystal wafer production likely generates wastewater in the form of slurries and acids and confirmed that nanodiamonds are used in sapphire crystal polishing slurries. In addition, EPA identified several facilities in the U.S. that are currently manufacturing sapphire crystals and wafers. Following these preliminary results, EPA concluded that further review of the E&EC ELGs was appropriate.

EPA promulgated the E&EC ELGs (40 CFR Part 469) in 1983. Given the age of the ELGs and the changes that have occurred in the industry since their promulgation, EPA expanded the current review to include the entire E&EC Category, not just sapphire crystal manufacturing. The 1983 ELGs set limitations for four subcategories: semiconductors, electronic crystals, cathode ray tubes (CRTs), and luminescent materials. EPA further evaluated each of the four subcategories to:

- Understand the current U.S. E&EC industry and the extent to which it has changed since the promulgation of the ELGs.
- Identify which E&EC manufacturers discharge wastewater, whether they discharge directly or indirectly, what pollutants are discharged, and what electronics and electrical components they manufacture.
- Further understand and identify changes to the manufacturing steps associated with new E&EC operations since the 1983 rulemaking that may impact wastewater characteristics or management.
- Evaluate advancements in wastewater treatment technologies employed by facilities in the E&EC industry.
- Evaluate how the E&EC ELGs are applied in active National Pollutant Discharge Elimination System (NPDES) permits.

Section 5.2.1 provides details on the E&EC ELGs. Section 5.2.2 describes the industry profile, including facility types, process operations, and wastewater discharge practices in 1983 and the present. Section 5.2.3 provides information on E&EC wastewater characteristics in 1983

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

and the present. Section 5.2.4 presents a summary of the treatment technology basis for the E&EC ELGs and EPA's review of existing wastewater treatment technologies. Section 5.2.5 provides a summary of EPA's review of the E&EC Category.

### 5.2.1 Overview of Existing E&EC Effluent Limitations Guidelines and Standards (ELGs)

EPA promulgated the existing E&EC ELGs (40 CFR Part 469) in 1983, which established the Best Practicable Control Technology (BPT), Best Available Technology Economically Achievable (BAT), Best Conventional Pollutant Control Technology (BCT), Pretreatment Standards for Existing Sources (PSES), New Source Performance Standards (NSPS), and Pretreatment Standards for New Sources (PSNS) for the E&EC industry. EPA divided the E&EC Industry into four subcategories based on manufacture of the following products: semiconductors, electronic crystals, CRTs, and luminescent materials. EPA promulgated the E&EC ELGs in two phases: Phase I, published in April 1983, contains the ELGs for Subparts A (semiconductors) and B (electronic crystals) (U.S. EPA, 1983a); and Phase II, published in December 1983, contains the ELGs for Subparts C (CRTs) and D (luminescent materials) (U.S. EPA, 1983b). Table 5-6 provides a summary of the regulated pollutants by subcategory for the 1983 E&EC ELGs.

**Table 5-6. Regulated Pollutants for the E&EC Category**

Subpart	Subcategory	Total Toxic Organics <sup>a</sup>	Antimony	Arsenic	Cadmium	Chromium	Fluoride	Lead	pH	TSS	Zinc
<b><i>BPT (Best Practicable Control Technology)</i></b>											
A	Semiconductors	✓							✓		
B	Electronic Crystals	✓		✓			✓		✓	✓	
<b><i>BAT (Best Available Technology Economically Achievable)</i></b>											
A	Semiconductors	✓					✓				
B	Electronic Crystals	✓		✓			✓				
<b><i>BCT (Best Conventional Pollutant Control Technology)</i></b>											
A	Semiconductors								✓		
B	Electronic Crystals								✓	✓	
<b><i>PSES (Pretreatment Standards for Existing Sources)</i></b>											
A	Semiconductors	✓									
B	Electronic Crystals	✓		✓							
C	Cathode Ray Tubes	✓			✓	✓	✓	✓			✓
<b><i>NSPS (New Source Performance Standards)</i></b>											
A	Semiconductors	✓					✓		✓		
B	Electronic Crystals	✓		✓			✓		✓	✓	
C	Cathode Ray Tubes	✓			✓	✓	✓	✓	✓	✓	✓
D	Luminescent Materials		✓		✓		✓		✓	✓	✓

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-6. Regulated Pollutants for the E&EC Category**

Subpart	Subcategory	Total Toxic Organics <sup>a</sup>	Antimony	Arsenic	Cadmium	Chromium	Fluoride	Lead	pH	TSS	Zinc
<i>PSNS (Pretreatment Standards for New Sources)</i>											
A	Semiconductors	✓									
B	Electronic Crystals	✓		✓							
C	Cathode Ray Tubes	✓			✓	✓	✓	✓			✓
D	Luminescent Materials		✓		✓		✓				✓

Source: (U.S. EPA, 1983a, 1983b)

TSS – Total Suspended Solids

<sup>a</sup> Total toxic organics (TTO) indicates the sum of the concentrations for each of the toxic organic compounds which are in the wastewater discharge at a concentration greater than 10 µg/L. Table 5-7 and Table 5-8 provide the list of regulated toxic organic compounds for Subparts A, B, and C.

EPA established the E&EC ELGs specific to each subcategory based on their different raw materials, final products, manufacturing processes, geographical location, plant-size and age, wastewater characteristics, non-water quality environmental impacts, treatment costs, energy costs, and solid waste generation (U.S. EPA, 1983a, 1983b). The following subsections describe the two phases of the E&EC ELG development in more detail, the wastewater treatment technology bases for the ELGs, and other point source categories related to E&EC.

#### 5.2.1.1 Phase I: Semiconductors and Electronic Crystals

In April 1983, EPA promulgated the Phase I E&EC ELGs for Subpart A (Semiconductors) and Subpart B (Electronic Crystals) (U.S. EPA, 1983a). As part of this rulemaking, EPA gathered industry analytical data to characterize wastewater discharges from semiconductor and electronic crystal manufacturing. EPA excluded 95 pollutants from regulation because they were 1) non-detectable with 1983 EPA analytical methods (82 pollutants), 2) present in concentrations too small to be effectively treated (antimony, beryllium, cadmium, mercury, selenium, thallium, zinc, and cyanide), or 3) subject to Metal Finishing ELGs (nickel, copper, chromium, and lead).<sup>44</sup> EPA ultimately established limitations for fluoride, toxic organics, arsenic, pH, and total suspended solids.<sup>45</sup> Since semiconductor and electronic crystal manufacturers use a wide variety of solvents, EPA identified several toxic organics that may be present in the untreated wastewater. Therefore, EPA established limitations for total toxic organics (TTO). EPA defined TTO, for Subparts A and B, as the sum of toxic organics listed in Table 5-7 with flow weighted mean concentrations greater than or equal to 0.01 milligrams per liter (mg/L) per pollutant (U.S. EPA, 1983a).

<sup>44</sup> See Section 5.2.1.4 for a discussion on the overlap between the E&EC and Metal Finishing ELGs.

<sup>45</sup> The E&EC ELGs reference the regulated pollutants for each subpart as the only pollutants of concern identified during the rulemaking (U.S. EPA, 1983a, 1983b).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

**Table 5-7. TTO Pollutants for Subpart A (Semiconductors) and Subpart B (Electronic Crystals)**

List of TTO Pollutants for Semiconductors and Electronic Crystals			
anthracene	1,3-dichlorobenzene	Isophorone	toluene
bis(2-ethylhexyl)phthalate	1,4-dichlorobenzene	methylene chloride	1,2,4-trichlorobenzene
butyl benzyl phthalate	Dichlorobromoethane	naphthalene	1,1,1-trichloroethane
carbon tetrachloride	1,2-dichloroethane	2-nitrophenol	1,1,2-trichloroethane
chloroform	1,1-dichloroethylene	4-nitrophenol	trichloroethylene
2-chlorophenol	2,4-dichlorophenol	pentachlorophenol	2,4,6-trichlorophenol
di-n-butyl phthalate	1,2-diphenylhydrazine	phenol	
1,2-dichlorobenzene	ethyl benzene	tetrachloroethylene	

Source: (U.S. EPA, 1983a).

### 5.2.1.2 Phase II: Cathode Ray Tubes and Luminescent Materials

In December 1983, EPA promulgated the Phase II E&EC ELGs for Subpart C (CRTs) and Subpart D (Luminescent Materials) (U.S. EPA, 1983b). EPA gathered industry analytical data to characterize wastewater discharged from the manufacture of CRTs and luminescent materials. EPA originally divided the Electron Tube subcategory into CRTs and Receiving and Transmitting Tubes (RTT) subcategories; however, RTT manufacturing operations do not discharge wastewaters and only promulgated limitations for CRTs. Further, EPA did not establish limitations for existing source direct dischargers in the CRT subcategory. Only one facility directly discharged, and it operated a chemical precipitation plus filtration treatment system and the discharge of toxic pollutants was less than two pounds per day after current treatment. Similarly, EPA did not establish limitations or pretreatment standards for existing dischargers in the Luminescent Materials subcategory due to the small number of facilities in the subcategory (five) and because the amount of toxic metals discharged to surface water (less than one pound per facility per day) and toxic pollutants introduced to publicly operated treatment works (POTWs) was insignificant at the time of promulgation (U.S. EPA, 1983b).

For CRT manufacturing, EPA excluded 116 pollutants from regulation because they were either non-detectable with 1983 EPA analytical methods (106 pollutants) or present in concentrations too small to be effectively treated (antimony, arsenic, beryllium, copper, mercury, nickel, selenium, silver, thallium, cyanide) (U.S. EPA, 1983b). EPA established limitations for cadmium, chromium, lead, zinc, TTO, fluoride, pH, and total suspended solids for the CRT manufacturing subcategory. Similar to semiconductors and electronic crystals, CRT manufacturers use a wide variety of solvents, and EPA identified several toxic organics that may be present in the untreated wastewater. Therefore, EPA established limitations for TTO. For the CRT subcategory, EPA defined TTO as the sum of the toxic organics listed in Table 5-8 with flow weighted concentrations greater than or equal to 0.01 milligrams per liter (mg/L) per pollutant (U.S. EPA, 1983b).

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-8. TTO Pollutants for Subpart C (CRTs)**

List of TTO Pollutants for CRTs		
chloroform	methylene chloride	1,1,1-trichloroethane
bis(2-ethylhexyl) phthalate	Toluene	trichloroethylene

Source: (U.S. EPA, 1983b).

For luminescent material manufacturing, EPA excluded 123 pollutants from regulation because they were either non-detectable with 1983 EPA analytical methods (114 pollutants) or present in concentrations too small to be effectively treated (arsenic, beryllium, copper, mercury, nickel, selenium, silver, thallium, cyanide). EPA established limitations for cadmium, antimony, zinc, fluoride, pH, and total suspended solids for the luminescent material subcategory (U.S. EPA, 1983b).

### 5.2.1.3 Wastewater Treatment Technology Bases for Pollutant Limitations in the E&EC Category

The E&EC ELGs established pollutant limitations for the E&EC Category generally based on solvent management<sup>46</sup> (to control TTO), neutralization, chemical precipitation with clarification (hydroxide), in-process control for specific pollutants,<sup>47</sup> and filtration. As previously stated, EPA did not establish BPT, BAT, and BCT limitations for CRTs or luminescent materials, or PSES for luminescent materials. Table 5-9 presents the general wastewater treatment technology basis by subcategory and level of control.

**Table 5-9. Wastewater Treatment Technology Bases for the E&EC Category**

Subpart	Subcategory	Solvent Management	Neutralization	Chemical Precipitation with Clarification <sup>a</sup>	In-Process Control for Lead and Chromium	Filtration
<b><i>BPT (Best Practicable Control Technology)</i></b>						
A	Semiconductors	✓	✓			
B	Electronic Crystals	✓	✓	✓		
<b><i>BAT (Best Available Technology Economically Achievable)</i></b>						
A	Semiconductors	✓	✓	✓		
B	Electronic Crystals	✓	✓	✓		
<b><i>BCT (Best Conventional Pollutant Control Technology)</i></b>						
A	Semiconductors	✓	✓			
B	Electronic Crystals	✓	✓	✓		

<sup>46</sup> In the E&EC ELGs, EPA defined solvent management as a practice of preventing spent solvent baths (containing TTO) from entering other process wastewater. While the ELGs allow for some solvent bath contamination (e.g., drag out), plants are required to transfer solvent baths to drums or tanks for disposal.

<sup>47</sup> In-process control includes the collection of lead- and chromium- bearing wastes for resale, reuse, or disposal.

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-9. Wastewater Treatment Technology Bases for the E&EC Category**

Subpart	Subcategory	Solvent Management	Neutralization	Chemical Precipitation with Clarification <sup>a</sup>	In-Process Control for Lead and Chromium	Filtration
<b><i>PSES (Pretreatment Standards for Existing Sources)</i></b>						
A	Semiconductors	✓				
B	Electronic Crystals	✓	✓	✓		
C	Cathode Ray Tubes	✓	✓	✓	✓	
<b><i>NSPS (New Source Performance Standards)</i></b>						
A	Semiconductors	✓	✓	✓		
B	Electronic Crystals	✓	✓	✓		
C	Cathode Ray Tubes	✓	✓	✓	✓	✓
D	Luminescent Materials		✓	✓		
<b><i>PSNS (Pretreatment Standards for New Sources)</i></b>						
A	Semiconductors	✓				
B	Electronic Crystals	✓	✓	✓		
C	Cathode Ray Tubes	✓	✓	✓	✓	✓
D	Luminescent Materials		✓	✓		

Source: (U.S. EPA, 1983a, 1983b)

<sup>a</sup> EPA based all subparts on end-of-pipe or final effluent chemical precipitation with clarification except Subpart A (Semiconductors), which was based on in-plant chemical precipitation and clarification of the concentrated fluoride stream. In addition, contract hauling of the concentrated fluoride stream was considered an acceptable alternative for compliance.

#### 5.2.1.4 Other Point Source Categories Related to E&EC

As stated above, EPA promulgated the existing E&EC ELGs (40 CFR Part 469) in 1983. EPA also promulgated the Electroplating ELGs in 1974 and amended them in 1977, 1979, 1981 and 1983 (40 CFR Part 413) and promulgated the Metal Finishing ELGs in 1983 (40 CFR Part 433). During promulgation of the E&EC and Metal Finishing ELGs and the amendments of the Electroplating ELGs, EPA considered that some facilities may generate wastewater from metal finishing and/or electroplating operations as well as E&EC operations; and therefore, facilities may be covered under multiple ELGs.

The Metal Finishing ELGs apply to discharges resulting from six core process operations, and 40 additional process operations for those facilities using at least one of the six core process operations (U.S. EPA, 1983c). The six core metal finishing process operations are electroplating, electroless plating, anodizing, coating, etching and chemical milling, and printed circuit board manufacturing (U.S. EPA, 1983c). Following the amendments of the Electroplating ELGs, EPA limited the applicability of the Electroplating Category ELGs to facilities that apply metal coatings via electrodeposition that began operation before July 15, 1983, and discharge wastes to

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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POTWs. All other facilities performing electroplating operations are subject to regulations under the Metal Finishing Category (U.S. EPA, 1983c).

As discussed in later sections, most semiconductor manufacturing facilities use one or more of the six core metal finishing operations while processing silicon wafers. The *Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Metal Finishing Point Source Category* states that the ELGs for the Metal Finishing Category, the Electroplating Category, and/or the E&EC Category cover all industries listed under SIC Major Group 36.<sup>48</sup> Specifically, the E&EC ELGs cover processes unique to electronics manufacturing (e.g., semiconductor manufacturing, electronic crystal production), while the Metal Finishing and Electroplating ELGs cover the remaining processes used to manufacture the products in SIC Major Group 36 (U.S. EPA, 1983c).

As described in the *Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Metal Finishing Point Source Category*, when overlap occurs between the Metal Finishing or Electroplating ELGs and E&EC ELGs, the Metal Finishing ELGs apply for the discharge of four pollutants (nickel, copper, chromium, and lead) (U.S. EPA, 1983c). For example, for a semiconductor manufacturing facility generating electroplating wastewater, the subpart A E&EC ELGs would apply for pollutants provided in Table 5-6 and the Metal Finishing ELGs would apply for four pollutants associated with metal finishing processes (nickel, copper, chromium, and lead). Note that EPA is currently conducting a preliminary study of the Metal Finishing Category; for more information, see the *Preliminary Study of the Metal Finishing Category: 2015 Status Report* (U.S. EPA, 2016a).

## 5.2.2 E&EC Industry Profile

As part of the current review, EPA reviewed the 1983 E&EC industry profile and updated the characteristics of the current E&EC industry. This section presents the facility type, wastewater discharge practices, and process operations for E&EC facilities in 1983 and currently. Section 5.2.3 presents information on E&EC wastewater characteristics, and Section 5.2.4 presents information on E&EC wastewater treatment technologies.

### 5.2.2.1 1983 E&EC Industry Profile

EPA developed an industry profile for the E&EC industry as part of the development of the Phase I and Phase II E&EC ELGs in 1983. To complete the industry profile, EPA gathered information through literature searches, EPA regional office contacts, wastewater treatment technology vendors, and plant surveys and evaluations. This section describes the 1983 facility information EPA gained from its data collection efforts.

#### *Facilities and Wastewater Discharge Practices*

During the 1983 E&EC rulemaking, EPA identified that the majority of facilities under the E&EC Category manufactured semiconductors (Subpart A) (approximately 72 percent). EPA estimated that about 20 percent of facilities within the E&EC Category manufactured electronic crystals (Subpart B), leaving approximately 8 percent of facilities under Subparts C (CRTs) and

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<sup>48</sup> SIC Major Group 36 includes Semiconductor and Related Manufacturing (SIC code 3674), Electron Tube Manufacturing (SIC code 3671), and Electronic Component Manufacturing (SIC code 3679).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

D (luminescent materials). Table 5-10 provides the facility count and discharge type identified during the 1983 E&EC rulemaking.

**Table 5-10. Facility Information for 1983 Industry Profile**

Subpart	Manufacturing Process	Facility Count <sup>a</sup>	Dischargers	
			Direct	Indirect
A	Semiconductor Manufacturing	257	77	180
B	Electronic Crystals	70	6	64
C	Cathode Ray Tubes	24	1	23
D	Luminescent Materials	5 <sup>b</sup>	2	2
<b>Total</b>		<b>356</b>	<b>86</b>	<b>269</b>

Source: (U.S. EPA, 1983a, 1983b)

<sup>a</sup> EPA identified the number of facilities using a Semiconductor Industry Association (SIA) listing of plants involved in manufacturing semiconductor products in August 1979.

<sup>b</sup> EPA identified one facility with zero discharges.

As shown in Table 5-10, in 1983, 76 percent of all facilities in the E&EC industry discharged to POTWs, including 70 percent of semiconductor manufacturing facilities, 91 percent of electronic crystal manufacturers, and 96 percent of CRT manufacturing facilities. EPA only reviewed five luminescent materials manufacturers, where 40 percent discharged to surface waters and 40 percent discharged to POTWs, while 20 percent achieved zero discharge (U.S. EPA, 1983a, 1983b).

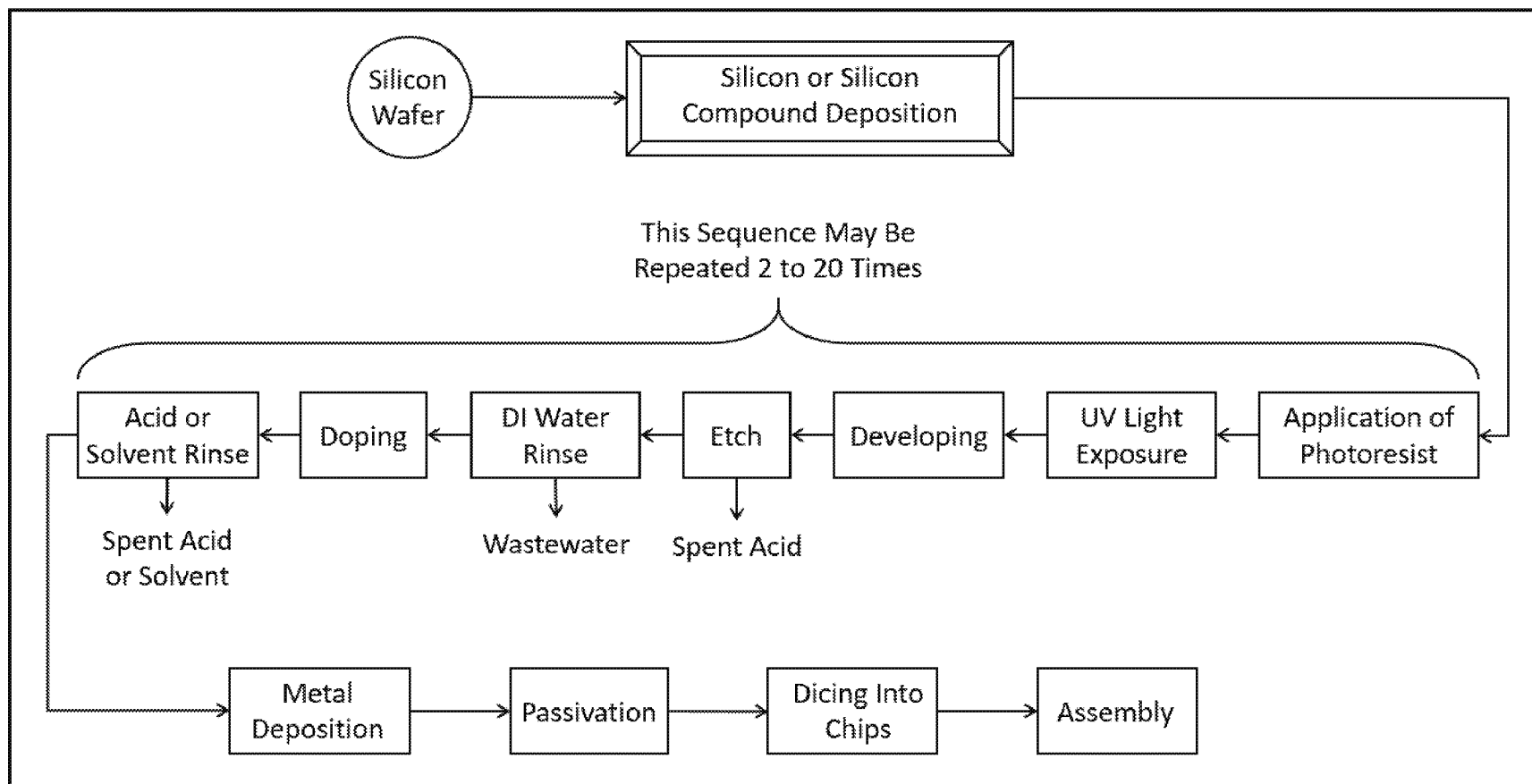
### ***E&EC Process Operations***

EPA reviewed information on the process operations for the four subcategories established in 1983: semiconductor manufacturing, electronic crystal manufacturing, cathode ray tube manufacturing, and luminescent materials manufacturing. The following sections summarize the results by subcategory.

#### **Semiconductor Manufacturing**

In general, semiconductor manufacturing facilities coat and chemically etch/pattern silicon wafers for the desired E&EC products. In 1983, semiconductor manufacturing involved a series of processes, possibly repeated two to 20 times, starting from a raw silicon wafer and ending in a chip designed for assembly in a specific electronic product. Figure 5-2 presents the sequence of process operations for manufacturing silicon integrated circuits (a semiconductor type), as identified in 1983.

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)



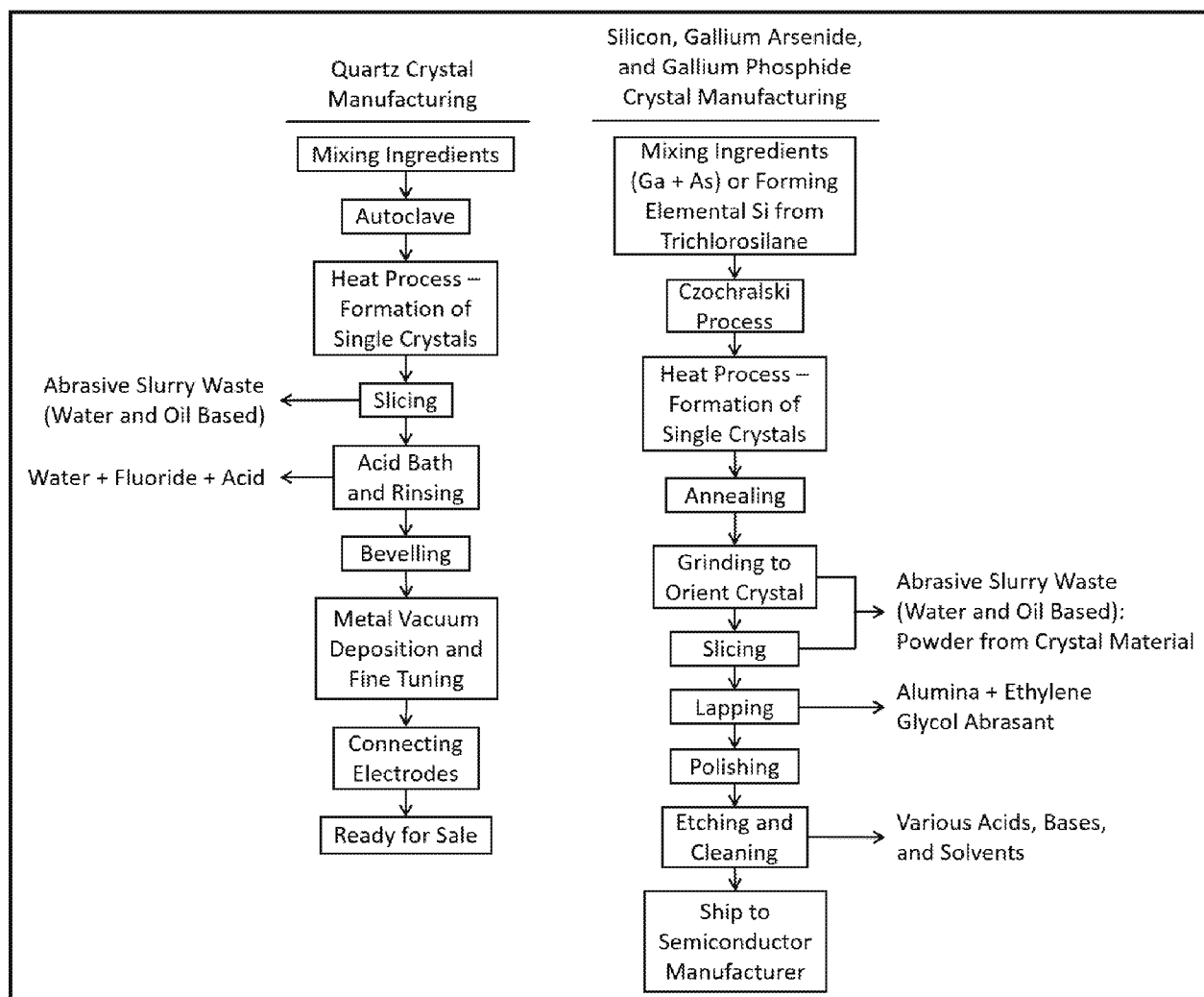
Source: Adapted from (ERG, 2016a; U.S. EPA, 1983a)

**Figure 5-2. 1983 Silicon Integrated Circuit Production**

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

### Electronic Crystals Manufacturing

EPA defined electronic crystal manufacturing as the growing of crystals and/or production of crystal wafers for use in the manufacture of electronic devices. In general, electronic crystal manufacturing involves forming a crystalline boule and then slicing, rinsing, lapping (e.g., grinding), polishing, etching, and cleaning the crystal prior to shipping to a semiconductor manufacturer or another electronics customer. Figure 5-3 shows diagrams of typical manufacturing process flows in 1983 for the manufacture of quartz crystals (a type of piezoelectric crystal), and three types of semiconducting crystals; silicon, gallium arsenide, and gallium phosphide. EPA only identified one sapphire crystal producer in 1983; therefore, sapphire crystal manufacturing was not a focus of the rulemaking. EPA reviewed sapphire crystal manufacturing as part of the 2015 Annual Review. Although this review suggested that sapphire crystals are currently a common type of electronic crystal manufactured and used in the E&EC industry (U.S. EPA, 1983a, 2016b).



Source: Adapted from (U.S. EPA, 1983a).

**Figure 5-3. Basic Manufacturing Processes for Electronic Crystals in 1983**

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

### Cathode Ray Tubes and Luminescent Materials Manufacturing

In 1983, CRT manufacturing operations differed depending on the type of CRT (e.g., color television (TV) tubes, single phosphor tubes). The manufacture of each type of CRT was highly complex and often automated (U.S. EPA, 1983b). The 1983 E&EC ELGs define luminescent materials as “those that emit electromagnetic radiation (light) upon excitation by such energy sources as photons, electrons, applied voltage, chemical reactions, or mechanical energy. These luminescent materials are used for a variety of applications, including fluorescent lamps, high-pressure mercury vapor lamps, color TV picture tubes and single phosphor tubes, lasers, instrument panels, postage stamps, laundry whiteners, and specialty paints” (U.S. EPA, 1983b). EPA based its 1983 analyses related to these two subcategories on those materials used as coatings in fluorescent lamps and color TV picture tubes and single phosphor tubes (U.S. EPA, 1983b).

#### **5.2.2.2 Existing E&EC Industry Profile**

As a first step in understanding the existing industry profile, EPA identified the relevant North American Industry Classification System (NAICS) and Standard Industrial Classification (SIC) codes that cover electronics and electrical component manufacturing facilities. Specifically, EPA reviewed the NAICS-Point Source Category (NAICS-PSC) and SIC-PSC crosswalks developed for the 304m Annual Review process,<sup>49</sup> the E&EC ELGs development documents, and the SIC industry Group 367 (Electronic Components and Accessories). From this review, EPA identified four NAICS codes and three SIC codes that correspond to facilities that may currently fall under the E&EC Category. Table 5-11 presents these NAICS and SIC codes.

**Table 5-11. NAICS and SIC Codes Under the E&EC Category**

Potential Applicable Subpart <sup>a</sup>	NAICS Code	NAICS Code Description	SIC Code	SIC Code Description
A, B	334413	Semiconductor and Related Device Manufacturing	3674	Semiconductor and Related Devices
A	333242	Semiconductor Machinery Manufacturing	NA	NA
C, D	NA	NA	3671	Electron Tubes
B, C, D	334419 <sup>b</sup>	Other Electronic Component Manufacturing	3679	Electronic Components, Not Elsewhere Classified

NA: Not applicable.

<sup>a</sup> EPA performed best professional judgement based on current knowledge of reported facility discharges to link the E&EC Category subpart to the corresponding NAICS and SIC code. Note that not all facilities classified under these NAICS and/or SIC codes will have associated wastewater discharges, or their discharges may not be covered under the identified E&EC Category subpart.

<sup>b</sup> In 2012, the U.S. Census Bureau discontinued NAICS code 334411 (Electron Tube Manufacturing), and consolidated all Electron Tube Manufacturing facilities under NAICS code 334419 (U.S. Census Bureau, 2016a).

<sup>49</sup> For further information on the NAICS-PSC and SIC-PSC crosswalks see the *Technical Support Document for the Annual Review of Existing Effluent Guidelines and Identification of Potential New Point Source Categories* (U.S. EPA, 2009).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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Using the NAICS and SIC codes identified above as a starting point, EPA gathered information about the existing E&EC industry, including number of facilities, existing operations, and discharge practices. Specifically, for its review of the existing industry profile, EPA:

- Evaluated the most recent U.S. Census Bureau Economic Statistics (economic census data) for the relevant NAICS codes.
- Downloaded and analyzed 2014 Discharge Monitoring Report (DMR) and Toxics Release Inventory (TRI) data for the relevant SIC and NAICS codes. Specifically, EPA extracted data from *TRILTOOutput2014\_v1* and *DMRLTOOutput2014\_v1*. Section 2.1 provides EPA's methodology for obtaining the DMR and TRI data and generating these databases.
- Reviewed E&EC Industry IBISWorld Reports for Semiconductor and Circuit Manufacturing (33441a) and Circuit Board and Electronic Component Manufacturing (33441b).
- Searched and downloaded available E&EC facility NPDES permits.
- Identified and reviewed information from a literature search. Appendix B presents details on the keyword searches used for the literature review.

In addition to reviewing the publicly available data sources listed above, EPA spoke with facility contacts, attended industry conferences, and held discussions with trade associations and POTW organizations. Specifically, EPA attended two annual conferences in 2016 held by the Semiconductor Equipment and Materials International (SEMI) trade association: the Advanced Semiconductor Manufacturing Conference (ASMC) SEMI Conference in Saratoga Springs, New York, and the SEMI Conference (SEMICON) West in San Francisco, California. The conferences provided information about trends, environmentally conscious practices, materials, and manufacturing processes in the semiconductor industry. EPA held discussions with the Semiconductor Industry Association (SIA), which provided information on the current state of semiconductor manufacturing. Specifically, SIA provided insight on how the semiconductor industry has changed since 1983 in terms of manufacturing processes generating wastewater, trends, new technologies, facility information, materials, process equipment, wastewater treatment, and discharge practices, and offered their perspective on the E&EC ELGs. EPA also met with NACWA members to discuss their experience with implementing the E&EC pretreatment standards and to identify any unique wastewater characteristics from new E&EC process operations that present challenges to POTWs (U.S. EPA, 2016c).

EPA evaluated the data collected from these efforts for their usefulness and quality in accordance with *The Environmental Engineering Support for Clean Water Regulations Programmatic Quality Assurance Project Plan (PQAPP)* (ERG, 2013). Appendix A provides details on data usability and the quality of data sources supporting the current review.

This section presents EPA's current understanding of the E&EC industry's profile, including E&EC facilities, discharge practices, market statistics, and operations.

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

### ***Facilities and Wastewater Discharge Practices***

EPA evaluated several data sources to identify the number, size, and type of facilities currently in the E&EC industry. Specifically, EPA reviewed DMR and TRI industrial wastewater discharge data, U.S. Economic Census data, and IBISWorld Industry Reports.

To understand the universe of E&EC facilities reporting wastewater discharges, as well as their discharge practices, EPA extracted the 2014 DMR and TRI data for the SIC and NAICS codes in the E&EC Category from *TRILTOOutput2014\_v1* and *DMRLTOOutput2014\_v1*, respectively, and identified the total number of direct and/or indirect dischargers for each industry code. The DMR and TRI datasets provide the most comprehensive source of information on existing wastewater discharges in the U.S. See Section 2.1 of this report for details on the utility and limitations of the DMR and TRI data and for EPA's methodology for obtaining the DMR and TRI data and generating these databases. In addition, EPA identified the total number of companies and facilities under each NAICS code using U.S. Economic Census data. Table 5-12 presents the U.S. Census company and facility counts as well as information on the discharge practices (direct, indirect, or both) for facilities with reported wastewater discharges to DMR and/or TRI by relevant NAICS (and SIC code, where applicable).

**Table 5-12. Facility Information for the Existing Industry Profile**

Potential Applicable Subpart <sup>a</sup>	NAICS (SIC) Code	Industry Description	U.S. Census Company Count <sup>b</sup>	U.S. Census Facility Count <sup>c</sup>	Dischargers (As Reported on DMRs and/or to TRI)			
					Total	Direct	Indirect	Both
A, B	334413 (3674)	Semiconductor and Related Device Manufacturing	793	862	70	4	63	3
A	333242	Semiconductor Machinery Manufacturing	168	184	3	0	3	0
B, C, D	334419 (3679)	Other Electronic Component Manufacturing	1,170	1,110	20	5	14	1
<b>Total</b>			<b>2,130</b>	<b>2,160</b>	<b>93</b>	<b>9</b>	<b>80</b>	<b>4</b>

Source: TRILTOOutput2014\_v1; DMRLTOOutput2014\_v1; (U.S. Census Bureau, 2016b)

<sup>a</sup> EPA performed best professional judgement based on current knowledge of reported facility discharges to link the E&EC Category subpart to the corresponding NAICS and SIC code. Note that not all facilities classified under these NAICS and/or SIC codes will have associated wastewater discharges, or their discharges may not be covered under the identified E&EC Category subpart.

<sup>b</sup> The "Company Count" represents E&EC parent companies based on 2012 Economic Census data, the most recent available data compiled for parent companies.

<sup>c</sup> The "Facility Count" represents E&EC establishments based on 2014 Economic Census data, the most recent available data compiled for establishments.

As shown in Table 5-12, EPA identified 93 facilities with 2014 DMR and/or TRI discharges greater than zero out of over 2,000 E&EC facilities in the U.S., according to the most recent economic census data. However, EPA notes that the large difference between the facility counts could be attributed to facilities that include, but are not limited to: (1) facilities listed in

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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the U.S. Economic Census data that are distributors or sales facilities, not manufacturers; (2) facilities that do not meet TRI-reporting thresholds; and (3) facilities that are classified as minor dischargers in DMR, and therefore are not captured in the DMR data. In addition, EPA notes the limitations of the DMR and TRI datasets (as discussed in Section 2.1).<sup>50</sup>

From review of the data sources listed above, EPA identified that the universe of dischargers in the E&EC industry appears to have decreased since 1983, however, EPA notes the apparent decrease may be attributed to some extent by the limitations of the DMR and TRI data, as they are not comprehensive of all discharges (see Section 2.1 for data source limitations). Additionally, the 1983 data is likely more inclusive as the information was provided directly from industry trade associations and may include small facilities not otherwise captured in the publicly available DMR and TRI data. EPA also identified that the overall discharge practices remain similar, with most facilities discharging to POTWs. The 2014 DMR and TRI data indicate that 10 percent of the facilities with reported discharges discharge directly to surface waters, 4 percent discharge to both surface waters and to a POTW, and 86 percent discharge to a POTW (see Table 5-12). While the publicly available data (i.e., DMR and TRI data) do not provide a complete profile of the E&EC industry, the existing profile indicates substantially fewer direct dischargers in the industry than in 1983, suggesting an industry-wide trend toward indirect discharge. EPA's discussions with SIA also indicated that no zero discharge semiconductor facilities exist in the U.S. to their knowledge, due to the difficulty of reusing waste streams and the necessity of using ultra-pure water for several process operations (ERG, 2016a).

To supplement EPA's understanding of the current E&EC industry, EPA also evaluated two 2016 IBISWorld Industry Reports for the U.S. E&EC industry: *Semiconductor and Circuit Manufacturing* (334411a) and *Circuit Board and Electronic Component Manufacturing* (33441b). The first report, *Semiconductor and Circuit Manufacturing*, estimates that there are 724 companies in the semiconductor and circuit manufacturing industry in 2016. This is similar to the U.S. economic census data estimate of 793 semiconductor manufacturing companies in 2012 (shown in Table 5-12). The second report, *Circuit Board and Electronic Component Manufacturing*, estimates that there are 2,758 circuit board and electronic component manufacturing companies in 2016, divided into the following products and/or service categories (IBISWorld, 2016a, 2016b):

- 40.1 percent printed circuits.
- 28.1 percent other electronic components.
- 13.0 percent electronic connectors.
- 10.4 percent bare printed circuit board.
- 8.4 percent capacitors, resistors, coils, and transformers.

These categories likely include facilities that also fall under the Metal Finishing Category. In addition, EPA recognizes that the E&EC Category may only cover facilities

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<sup>50</sup> Further discussion of the scope and limitations of the DMR and TRI datasets is available in the 2015 Annual Review Report (U.S. EPA, 2016b).

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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manufacturing products under the “other electronic components” category, or approximately 775 facilities.

Both IBISWorld Reports show that the top two E&EC manufacturing states are California and Texas, with over 25 percent of the establishments, combined (IBISWorld, 2016a, 2016b). EPA also evaluated the location of E&EC facilities reporting discharges to DMR or TRI in 2014 and, consistent with IBISWorld data, estimated that over 25 percent of those E&EC facilities are located in California or Texas.<sup>51</sup>

The U.S. Economic Census and IBISWorld report data convey that there are currently between 700 and 800 semiconductor manufacturing companies in the U.S. However, EPA has identified a data gap in its current understanding of the discharge practices of these semiconductor manufacturing facilities as well as other types of E&EC facilities, based on the limitations of the publicly available DMR and TRI data. Therefore, EPA cannot at this time definitively estimate the number of existing facilities under the E&EC Category with wastewater discharges; although the available data do indicate that the E&EC industry is primarily comprised of semiconductor manufacturing facilities and facilities discharging to POTWs. Additionally, the E&EC industry likely has few, if any, zero discharging facilities, based on discussions with SIA and NACWA (ERG, 2016a; U.S. EPA, 2016c).

### ***E&EC Market Statistics and Trends***

To further understand changes in the E&EC market over time, EPA reviewed information provided by SIA, presented at industry conferences, and discussed in the IBISWorld Reports for the E&EC industry. SIA estimates that the global semiconductor market has grown from \$21 billion in 1986 to \$335 billion in 2015 (ERG, 2016a). In addition, the IBISWorld Report values the U.S. Semiconductor and Circuit Manufacturing industry at \$54.2 billion in 2016 (IBISWorld, 2016a). While the semiconductor industry is globalized, more than 50 percent of U.S. headquartered firms' semiconductor manufacturing capacity is in the U.S. (ERG, 2016a).

Several speakers at the ASMC SEMI and the SEMICON West conferences also focused presentations and discussion on how the Internet of Things (IoT) will affect every economic sector (e.g., manufacturing, real estate, agriculture, retail, and transportation). IoT links the physical world (e.g., machinery, buildings, vehicles) to the digital world via electronics, sensors, and network connectivity. The semiconductor industry is essential to the digital world because IoT process control technologies, factory digitization, virtual manufacturing, and digital services will rely on new semiconductor designs and applications. Therefore, the semiconductor industry is expected to see increasing demand for products associated with IoT (ERG, 2016b, 2016c; Marone, 2016).

In contrast, the IBISWorld Report states that the Circuit Board and Electronic Component Manufacturing industry sector, which produces printed circuits, other electronic components, electronic connectors, bare printed circuit boards, capacitors, resistor coils, and transformers, is in the decline phase of its life cycle. In the decline phase, typically industry revenue grows slower than the economy, large firms control a majority of the industry,

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<sup>51</sup> All facilities under the NAICS and/or SIC codes listed in Table 5-11 reporting a pollutant load greater than zero pounds per year.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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technology and processes do not change significantly, and per capita consumption of industry products decreases (IBISWorld, 2016b). The circuit board and electronic component manufacturing industry sector produces several products that may not fall under the applicability of the E&EC ELGs. For example, printed circuits most likely fall under the applicability of the Metal Finishing category. Moreover, IBISWorld estimates that product demand will continue to decline for specific markets. For instance, electron tubes (e.g., CRTs), which fall under the “other electronic components” product designation in the IBISWorld Circuit Board and Electronic Component Manufacturing Industry, accounted for less than 1.5 percent of the industry revenue over the past five years, mostly due to their obsolescence (IBISWorld, 2016b).

### ***E&EC Process Operations***

Since 1983, EPA has observed changes in E&EC process operations in all four subcategories. EPA evaluated economic census data, analyzed DMR and TRI data, performed a literature search, searched for available NPDES reports, reviewed IBISWorld reports, met with industry trade associations and NACWA members, contacted individual facilities, and attended industry conferences, to identify the nature of current E&EC process operations (see the introduction to Section 5.2.2.2 for data collection methods). The following sections summarize the results by subcategory.

### ***Semiconductor Manufacturing***

Discussion with SIA indicated that while the semiconductor manufacturing (Subpart A) process sequence has not changed significantly, semiconductor manufacturing facilities (the semiconductor manufacturing industry refers to these facilities as fabrication plants or “fabs”) have added several process steps over the past 30 years to optimize semiconductor manufacturing, incorporate newer technologies, and achieve smaller node size. The node size, which indicates how densely individual transistors can be packed on a chip, has decreased approximately every two years since 1970, thereby doubling the number of transistors per square inch. The E&EC Industry refers to this observation as Moore’s Law (ERG, 2016b). When the number of transistors on a chip increases, the computational capabilities increase, speed increases, and energy consumption decreases. Since 2010, the node size decreased from 32 nanometers (nm), to 22 nm, to 14 nm, and now 10 nm (estimated for 2017 operations) (ERG, 2016a, 2016b).

In addition to the node size decreasing, the semiconductor industry has increased the silicon wafer size over the past 30 years, from a diameter of 125 millimeters (mm), to 200 mm, to 300mm, and now 450mm (estimated for 2017 operations) (ERG, 2016a, 2016b). By seeking to decrease the node size and increase the wafer size as much as feasible, the industry continually increases the number of microprocessors obtainable from a single wafer, to the limits of the technology available (Aldrich, 2016). Furthermore, as the technology advances, semiconductor manufacturing facilities must replace machines, tools, and monitoring systems to support new processes.

More specifically, to increase the number of microprocessors obtainable from a single wafer over the past 30 years, semiconductor manufacturing facilities have integrated new steps within the semiconductor manufacturing process sequence including dry etching, metal deposition processes (e.g., plating, chemical vapor deposition (CVD), copper metallization),

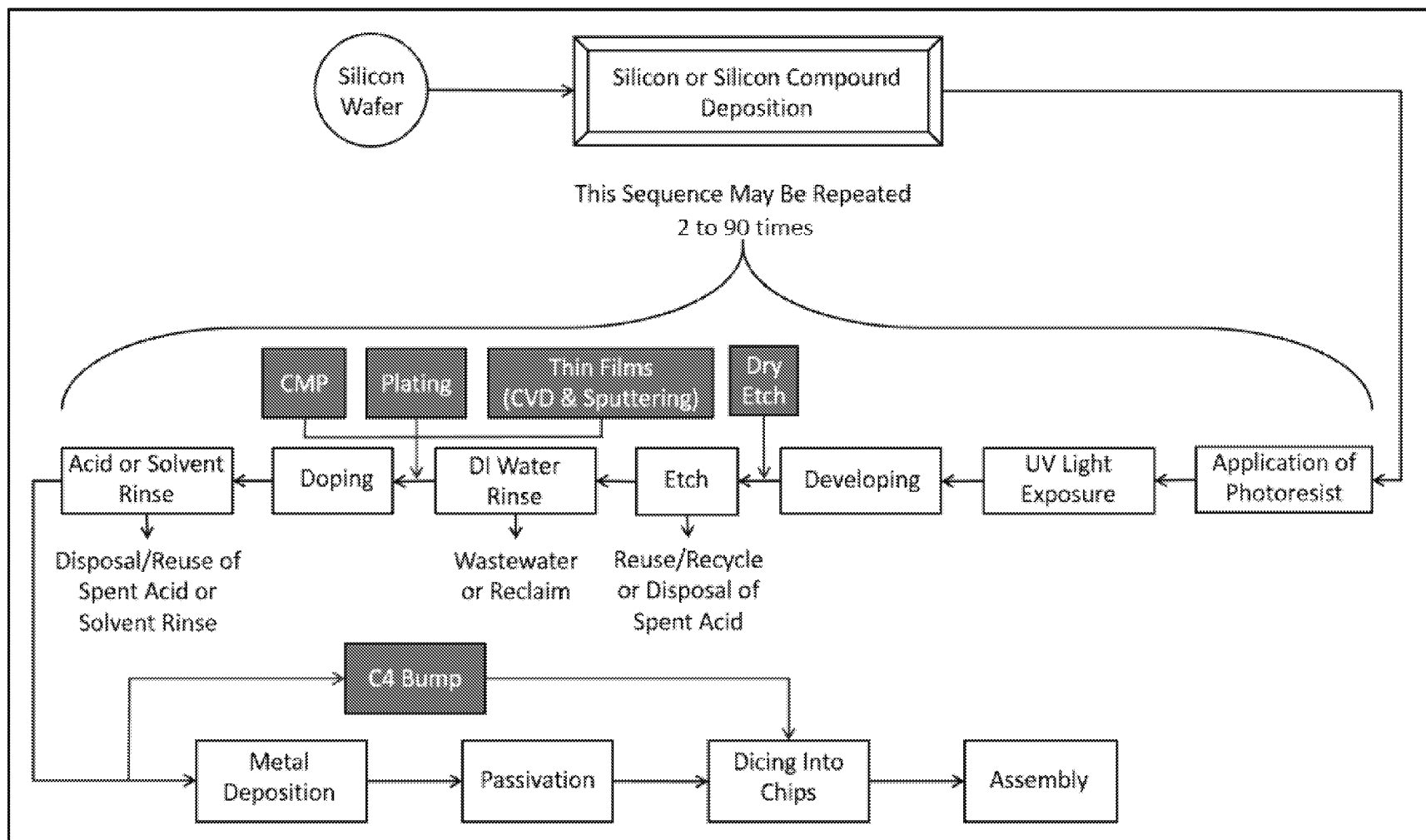
5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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chemical mechanical planarization (CMP), and controlled collapse chip connection (C4) bump. SIA indicated that wastewater is generated from these new processes but did not provide further details. In addition to new process steps, SIA stated that the existing semiconductor process sequence could be repeated up to 90 times, whereas in 1983 the sequence was repeated only up to 20 times. Therefore, the existing semiconductor process sequence could potentially generate greater volumes of wastewater due to the repetition of process steps and necessity for ultrapure water (i.e., rinse water cannot always be recycled because of the high-water quality requirement). Figure 5-4 provides the 1983 process flow diagram from the E&EC ELGs with updated semiconductor manufacturing operations based on EPA's discussions with SIA (ERG, 2016a; U.S. EPA, 1983a, 1998). In discussions with NACWA members, one member stated that semiconductor manufacturing evolves rapidly, and companies may tear down one semiconductor manufacturing facility to build another in a year. In addition, the NACWA member stated that process chemistries used in semiconductor manufacturing can be facility and/or product-specific and may not be consistent across the industry nationwide.

To further understand existing processes, EPA contacted six semiconductor facilities. EPA identified these facilities by evaluating available DMR and TRI data from *TRILTOOutput2014\_v1* and *DMRLTOOutput2014\_v1* for NAICS/SIC code listed in Table 5-11. EPA focused on facilities discharging the highest toxic weighted-pound equivalents (TWPE) based on reported 2014 DMR and TRI data. For facilities with the highest TWPE identified from the TRI data, EPA prioritized those that based their TRI releases on monitoring data (rather than using other estimation strategies). EPA inquired about the facility's age, size, manufacturing processes, end-products, process chemistries, wastewater generation, and wastewater treatment technologies. Table 5-13 presents a summary of information EPA obtained from these facility contacts. The facility contacts generally stated that the final products in semiconductor manufacturing have continued to shrink in size causing some fabrication processes to change (e.g., tooling, lithography patterns, new coating layers, CVD) (Aldrich, 2016; Heironimus, 2016; McCoy, 2016). Most of the contacts indicated that process chemistries (i.e., chemicals used in E&EC processes) have not changed substantially over the past 30 years; however, one facility stated that the chemistry changes would likely involve trading out one acid for another acid (McCoy, 2016).

5—EPA's Review of Additional Industrial Categories  
 Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)



Source: Adapted from (ERG, 2016a).

Note: Process steps in black writing and grey boxes represent the 1983 semiconductor manufacturing operations and process steps in white/red writing and red boxes represent updated semiconductor manufacturing operations since 1983.

**Figure 5-4. Updated Silicon Integrated Circuit Production**

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-13. Summary of Facility Contacts for the Semiconductor Industry**

Facility Name	Location	Manufacturing Process	Year/Age	Size <sup>a</sup>	Type	Wastewater Generation Processes	Wastewater Treatment <sup>b</sup>
East Fishkill Facility	Hopewell Junction, NY	Semiconductor 300 mm fab	1963 53 yrs	40 MGD 168,000 wafers/yr	Direct	<ul style="list-style-type: none"> <li>• Ultrapure water reject</li> <li>• Photolithography (i.e., solvents, rinses)</li> <li>• Polishing</li> </ul>	<ul style="list-style-type: none"> <li>• Clarifiers</li> <li>• CP (polymer)</li> <li>• Microfiltration</li> <li>• Acid base slurry treatment</li> <li>• Calcium hydroxide precipitation (Fluoride treatment)</li> <li>• Recycle 10 to 11 million gal/month (i.e., for use in 2<sup>nd</sup>/3<sup>rd</sup> rinses)</li> </ul>
Powerex, Inc.	Youngwood, PA	Semiconductor	1965 51 yrs	0.1 MGD	Direct	<ul style="list-style-type: none"> <li>• Rinsing after etching</li> <li>• Cleaning products throughout process</li> </ul>	<ul style="list-style-type: none"> <li>• Contact did not provide wastewater treatment information.</li> </ul>
Micron Technology, Inc.	Manassas, VA	Semiconductor 300 mm fab	1997 19 yrs	200 MGD	Both	<ul style="list-style-type: none"> <li>• Throughout manufacturing process (rinse water)</li> </ul>	<ul style="list-style-type: none"> <li>• Clarifiers</li> <li>• pH adjustment</li> <li>• Chloride treatment</li> <li>• Lime addition with filter tank</li> </ul>
Samsung Austin Semiconductor	Austin, TX	Semiconductor	1996 20 yrs	1.3 billion gal/yr	Indirect	<ul style="list-style-type: none"> <li>• Ultrapure water reject</li> <li>• Rinsing after etching</li> <li>• Cleaning products throughout process</li> </ul>	<ul style="list-style-type: none"> <li>• Clarifiers</li> <li>• CP (sodium hydroxide, lime, caustic, sulfuric acid, ferric chloride)</li> <li>• Filter presses</li> <li>• <i>Future Wastewater Treatment: Ion Exchange (Cu Treatment)</i><sup>c</sup></li> </ul>
Freescall Semiconductor – Oak Hill Facility	Austin, TX	Semiconductor	1991 25 yrs	240,000 wafers/yr	Indirect	<ul style="list-style-type: none"> <li>• Ultrapure water reject</li> <li>• Rinsing after etching</li> </ul>	<ul style="list-style-type: none"> <li>• pH adjustment</li> <li>• Recycle a portion of rinse water (i.e., for use in cooling tower, scrubber)</li> </ul>
Intel Corporation	Chandler, AZ	Semiconductor 12 in wafer	1994 22 yrs	5.4 MGD	Indirect	<ul style="list-style-type: none"> <li>• Wet edging</li> <li>• Abatement technologies</li> <li>• Rinsing after etching</li> <li>• Cleaning products throughout process</li> </ul>	<ul style="list-style-type: none"> <li>• Fluoride Treatment (i.e., creates calcium fluoride cake)</li> <li>• Stripper scrubber (NH<sub>3</sub> Treatment)</li> <li>• Zeolite resin (NH<sub>3</sub> Treatment)</li> <li>• Electrowinning System (Cu Treatment)</li> </ul>

Source: (Aldrich, 2016; Heironimus, 2016; Kang, 2016; Marone, 2016; McCoy, 2016; Wasielewski, 2016).

<sup>a</sup> MGD – million gallons per day discharged; Production rate (i.e., number of wafers).

<sup>b</sup> CP – Chemical Precipitation.

<sup>c</sup> Future Wastewater Treatment – The facility is considering installing ion exchange for copper treatment in effluent (i.e., performing pilot studies).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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### ***Electronic Crystals Manufacturing***

EPA reviewed electronic crystal manufacturing as part of the 2015 Annual Review and concluded sapphire crystal manufacturing has likely increased in the U.S. since the 1983 E&EC rulemaking. EPA also concluded that sapphire crystal wafer production generates wastewater in the form of slurries and acids from processing steps including wafer lapping, wafer grinding, and polishing similar to the processing steps for the production of other types of electronic crystals. Wafer lapping involves using an abrasive liquid slurry mixture to form a smooth, polished surface, while wafer grinding uses oil- or water-based slurries for coarse removal of material. Polishing slurries are used for surface polishing and removing abrasives; however, these slurries may introduce water, oil, and acid-based additives, as well as harsh chemicals, to the process wastewater. However, EPA's information on the wastewater constituents associated with sapphire crystal manufacturing is limited as the chemicals used in the preparation of sapphire wafers have not been thoroughly studied (U.S. EPA, 2016b).

For the current review, EPA conducted a targeted literature review using the keyword list found in Appendix B and did not identify any further information with regard to sapphire crystal manufacturing. However, EPA identified one paper with specific information regarding treatment of wastewater from electronic crystal polishing (Sturgill, et al., 2000). Sturgill primarily discusses pollution prevention and recycling of gallium and arsenic from gallium arsenide (GaAs) polishing wastes, but the introduction provides a general description of GaAs crystal manufacturing. Sturgill states that boules (i.e., ingots of crystalline GaAs) are cut into wafers, and then the wafers are etched, lapped, and polished (Sturgill, et al., 2000). Sturgill's GaAs crystal manufacturing process steps are similar to electronic crystal manufacturing process steps depicted in Figure 5-3 identified during the 1983 rulemaking. This information suggests the electronic crystal manufacturing process steps have not changed substantially over the past 30 years; however, as identified during the 2015 Annual Review, sapphire crystal manufacturing has likely increased.

### ***Cathode Ray Tubes and Luminescent Materials Manufacturing***

EPA reviewed existing manufacturing operations for Subpart C, CRTs, and Subpart D, luminescent materials, through internet searches and the literature review. The research indicates that CRT manufacturing has decreased dramatically due to their replacement with newer technologies, such as liquid crystal display (LCD), thin-film transistor liquid crystal display (TFT-LCD), plasma display, and organic light-emitting diode (OLED) for TV and other electronic applications (IBISWorld, 2016b; Sood & Tellis, 2005). Similarly, luminescent materials consisted of fluorescent lamp phosphors in 1983 (i.e., used in TV, video game displays, and lamp applications); however, most of these applications have been replaced with other technologies, such as light-emitting diode (LED) lamps and the CRT replacement technologies listed previously (ERG, 2016a; IBISWorld, 2016b; Sood & Tellis, 2005). In addition, NACWA members confirmed that CRT and luminescent materials are phasing out of production (U.S. EPA, 2016c).

#### ***5.2.3 E&EC Wastewater Characteristics***

EPA evaluated several data sources to identify existing E&EC wastewater characteristics (see the introduction to Section 5.2.2.2 for data collection methodology). First, EPA analyzed

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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publicly available data, such as the 2014 DMR and TRI data, to identify the types of pollutants that facilities reported as currently discharged. EPA analyzed these data to identify the number and percent of facilities reporting each pollutant, discharge type (e.g., direct, indirect, or both), pollutant load, and TWPE. Table 5-14 provides this information for facilities reporting 2014 DMR and/or TRI data and identifies whether E&EC ELGs establish limitations for the reported pollutant. As previously mentioned, EPA notes the limitations of the DMR and TRI datasets, as DMR data are limited to pollutants that a facility is required to monitor for in a discharge permit and TRI data are limited to pollutants on the TRI Chemicals list (see Section 2.1 of this report for details on the utility and limitations of the DMR and TRI data).

From the available DMR and TRI data, EPA identified 28 pollutants in E&EC wastewater discharges as summarized on Table 5-14. Of these pollutants, four have limitations established under the E&EC ELGs (i.e., lead, cadmium, chromium, and TSS) and eight have limitations established under the Metal Finishing ELGs (copper, lead, cadmium, chromium, nickel, cyanide compounds, TSS, and oil and grease), which may apply for E&EC facilities that have metal finishing operations. Further, more than 45 percent of facilities reported discharges of five pollutants (nitrate, lead, nitric acid, hydrogen fluoride, and n-methyl-2-pyrrolidone) of which lead is regulated under the CRT subcategory of the E&EC ELGs. However, as shown in Table 5-14, the overall discharge of each pollutant is small, except for nitrate, which accounts for approximately 60 percent of the total pounds discharged for the category. Although EPA did not identify additional pollutants of concern that could be removed by the technology bases evaluated for the 1983 ELGs (see Table 5-4 for information on the E&EC ELGs treatment technology bases), EPA notes that some of the pollutants listed in Table 5-14 may in fact be treated to some degree with current treatment in-place; however, EPA has not investigated the ancillary removal of additional pollutants at this time.

For the facilities reporting 2014 DMR data and included in Table 5-14, EPA attempted to collect publicly available NPDES permit documentation, but did not identify any relevant permits for analysis.

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-14. Discharge Data for Pollutants Reported to 2014 DMR and TRI with Pollutant Load Greater than Zero**

Pollutant	Count of Facilities Reporting Pollutant	Percent of Facilities Reporting Pollutant	Discharge Type	DMR	TRI	Pounds	TWPE	Pollutants with Limitations Under 1983 E&EC ELGs <sup>a</sup>
Nitrate	46	48%	Both		✓	2,180,000	1,630	-
Copper	22	23%	Both		✓	1,660	1,030	*
Ammonia as N	37	39%	Both	✓	✓	333,000	369	-
Sodium Dimethyldithiocarbamate	1	1%	Indirect		✓	2,380	190	-
Ethylene Glycol	22	23%	Both		✓	65,100	87.3	-
Total Residual Chlorine	7	7%	Direct	✓		146	73.1	-
Lead	80	84%	Both		✓	28	62.7	C*
Manganese	3	3%	Both	✓	✓	526	54.2	-
Cadmium	1	1%	Indirect		✓	1	22.8	C, D*
Certain Glycol Ethers	13	14%	Indirect		✓	135,000	14.4	-
Nitric Acid	54	57%	Indirect		✓	2,840	2.12	-
Chromium	2	2%	Both		✓	28	1.96	C*
Nickel	4	4%	Both		✓	17.3	1.73	*
Mercury	4	4%	Indirect		✓	0.00355	0.391	-
Catechol	1	1%	Indirect		✓	16.2	0.162	-
Hydrogen Fluoride	63	66%	Indirect		✓	11,600	0.0652	-
Trichloroethylene	3	3%	Direct	✓		3.55	0.0355	-
Iron	1	1%	Direct	✓		3.39	0.019	-
Cyanide Compounds	1	1%	Indirect		✓	0.45	0.00243	*
Xylene (Mixed Isomers)	5	5%	Indirect		✓	0.04	0.000173	-

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-14. Discharge Data for Pollutants Reported to 2014 DMR and TRI with Pollutant Load Greater than Zero**

Pollutant	Count of Facilities Reporting Pollutant	Percent of Facilities Reporting Pollutant	Discharge Type	DMR	TRI	Pounds	TWPE	Pollutants with Limitations Under 1983 E&EC ELGs <sup>a</sup>
Methylene chloride	1	1%	Direct	✓		0.024	0.0000243	-
1,1-Dichloroethane	1	1%	Direct	✓		0.0131	0.0000067	-
Total Dissolved Solids	1	1%	Direct	✓		736,000	-	-
N-Methyl-2-Pyrrolidone	45	47%	Indirect		✓	51,700	-	-
Total Suspended Solids	8	8%	Direct	✓		47,400	-	B, C, D*
Biochemical Oxygen Demand	6	6%	Direct	✓		8,550	-	-
Oil and grease	5	5%	Direct	✓		67.9	-	*
Phosphorus	1	1%	Direct	✓		18.8	-	-
<b>Total</b>	<b>95<sup>b</sup></b>	<b>100%</b>				<b>3,580,000</b>	<b>3,540</b>	

Source: *TRILTOOutput2014\_v1*; *DMRLTOOutput2014\_v1*

Note: The metal finishing ELGs have limitations for cadmium, chromium, copper, lead, nickel, cyanide, total suspended solids, and oil and grease. These limitations may apply for E&EC facilities with metal finishing operations, noted with an asterisk in the table.

\* An asterisk indicates that metal finishing ELGs may apply for E&EC facilities with metal finishing operations. The metal finishing ELGs have limitations for cadmium, chromium, copper, lead, nickel, cyanide, total suspended solids, and oil and grease.

<sup>a</sup> The subpart is listed for the pollutants that have limitations under the E&EC ELGs: A - Semiconductors; B - Electronic Crystals; C - CRT; D - Luminescent Materials. The 24 pollutants that do not have limitations under the E&EC ELGs may be controlled by the technology basis used to develop the established ELGs.

<sup>b</sup> Represents the total number of facilities under the E&EC NAICS and/or SIC codes listed in Table 5-11 with a pollutant load greater than zero in *TRILTOOutput2014\_v1* and/or *DMRLTOOutput2014\_v1*.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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To further understand current E&EC wastewater characteristics, EPA conducted a literature review, attended industry conferences, and contacted several facilities (see Section 5.2.2.2 for EPA's methodology for selecting facilities to contact), trade associations, and NACWA members.

SIA has indicated that as the industry has evolved according to Moore's Law,<sup>52</sup> it has adapted new tools, chemicals, materials, and operations. Since the 1980s, the semiconductor industry has incorporated up to 49 additional chemical elements into semiconductor manufacturing operations (ERG, 2016a). EPA's research confirmed that new manufacturing processes, operation practices, and chemicals adopted by the E&EC industry that may result in discharges of some of the pollutants listed in Table 5-14. For instance, some semiconductor manufacturing facilities use copper metallization, which was introduced in the 1990s and is an alternative to aluminum interconnects (ERG, 2016a). Similarly, a presentation at the ASMC SEMI Conference discussed a semiconductor manufacturing facility, which uses copper metallization for their Through-Silicon Via (TSV) process (Gopalakrishnan, et al., 2016). Therefore, semiconductor facilities, which have incorporated copper metallization into manufacturing processes since the 1983 E&EC ELGs, may discharge copper in their wastewater because of this operational change (see Table 5-14). In addition, SIA provided information on the abatement of fluorinated greenhouse gases (used in chamber cleaning) resulting in fluoride in semiconductor wastewaters via wet scrubbers (ERG, 2016a).

EPA's research also identified that the semiconductor industry has developed several new process chemistries for photolithography over the past 30 years. Photolithography patterns a wafer using the steps illustrated in Figure 5-4. For example, the industry uses new solvent systems, such as ethyl lactate and propylene glycol monomethyl ether acetate (PGMEA). Also, semiconductor manufacturing facilities commonly use aqueous developers for photoresists, which contain tetramethyl ammonium hydroxide (TMAH). CMP slurries, used to chemically and physically polish the wafer surface, typically contain low concentrations of engineered nanomaterials (for further information on EPA's review of engineered nanomaterials see Section 6.1) (ERG, 2016a).

In addition, some newer, chemically amplified photoresists and antireflective coatings can contain perfluoroalkyl substances (e.g., perfluorooctanesulfonic acid (PFOS)). A study on treatment of PFOS in semiconductor wastewater points out that PFOS is primarily used in photolithography because of its unique properties, including optical characteristics and acid-generating efficiency (Tang, et al., 2006). Specifically, during photolithography the semiconductor industry uses PFOS in photoresist (0.02 percent to 0.1 percent PFOS concentration), antireflective coating (0.1 percent PFOS concentration), and developer solutions (0.01 percent to 1.0 percent PFOS concentration). While most photolithography waste is handled as solvent and incinerated, Tang indicates that some facilities send approximately 40 percent of waste antireflective coating (containing PFOS) to wastewater treatment. Due to the unique chemical properties of PFOS, Tang indicates that it could take the semiconductor industry 10 years to 15 years to identify a PFOS substitute. Therefore, the semiconductor industry continues

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<sup>52</sup> Moore's Law is the observation that the number of transistors per square inch on semiconductors has doubled approximately every two years since 1970 (see Section 5.2.2.2 for Moore's Law explanation).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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to use PFOS for photolithography processes. The European Union proposed to ban the use of PFOS in 2006 (Tang, et al., 2006).

Despite rapid advances within the industry and changing operations and process chemistries, SIA indicated that semiconductor manufacturing requires specialized chemicals that operate precisely with advanced equipment and materials, and that offer distinctive functionality to accomplish high yield, high volume manufacturing. SIA asserted that chemical alternatives may not be available (or known) for use within the industry for certain operations. SIA indicated that researching chemical alternatives and incorporating them into a semiconductor manufacturing process might take 10 to 15 years.

Through facilities contacted as part of the current review (discussed in Section 5.2.2.2) EPA learned that some of the chemicals previously used in semiconductor manufacturing operations have been replaced. For instance, one facility noted that trichloroethylene had been phased out of operations 20 years ago (Wasielewski, 2016). Although some hazardous chemicals, PFOS for example, are difficult to replace in certain semiconductor manufacturing process steps. SIA stated that TTO have been eliminated from lithography and the industry has tried to eliminate or minimize other constituents of concern in specific process steps (e.g., organic solvents, ozone depleting substances, lead from assembly or packaging) (ERG, 2016a).

NACWA members stated that pollutants such as ammonia, nitrogen, sulfate, fluoride, and copper are becoming more prevalent in discharges from E&EC facilities. Additionally, due to water conservation programs, E&EC facilities are using less water; therefore, increasing the concentration of pollutants in the water discharged to POTWs (U.S. EPA, 2016c).

In summary, through various data sources described previously, EPA learned that E&EC wastewater characteristics have likely changed since 1983. Research indicates that the industry may be discharging several new pollutants not considered at the time of the 1983 rulemaking, and that are not reported to DMR or TRI, including some toxic pollutants (e.g., TMAH, PFOS) that are used in various semiconductor manufacturing processes. In addition, industry may be discharging more substantial quantities of certain previously considered and/or regulated pollutants including copper and fluoride due to manufacturing process changes. Additionally, as indicated by SIA, some facilities may have phased out the use of other pollutants regulated as part of the 1983 ELGs, such as TTO.

#### **5.2.4 E&EC Wastewater Treatment Technologies**

The E&EC ELGs established limitations for the E&EC Category generally based on solvent management to control TTO, neutralization, chemical precipitation with clarification (hydroxide), in-process control for specific pollutants, and filtration. See Section 5.2.1.3 for further details on the wastewater treatment technologies used to establish the E&EC ELGs.

To understand current wastewater treatment technologies and practices, EPA contacted several facilities and trade associations, conducted a literature review, and reviewed information available in EPA's Industrial Wastewater Treatment Technologies (IWTT) Database. For the facility contacts, EPA compiled a summary of the facility type, wastewater generation processes, and wastewater treatment technologies employed (see Section 5.2.2.2 for EPA's methodology for selecting facilities to contact). Most of the facilities contacted use the wastewater treatment

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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technologies established in the E&EC ELGs; however, some facilities employ, or plan to employ, more advanced wastewater treatment. Biological treatment, ion exchange, electrowinning, and zeolite resin systems are examples of such advanced wastewater treatments. Table 5-13 provides a summary of the wastewater treatment information obtained from the facility contacts. While some of the facilities contacted are direct dischargers, SIA indicated that the vast majority of semiconductor manufacturing facilities pretreat semiconductor wastewater, through processes such as pH adjustment or neutralization, prior to discharging to a POTW, and use dedicated solvent waste drains and collection systems (ERG, 2016a). Some facilities will collect organic wastes for reuse (e.g., isopropyl alcohol, n-methyl pyrrolidone) (ERG, 2016a). SIA explained that some semiconductor manufacturing plants have implemented water reuse practices, such as using RO reject water in other process operations (e.g., scrubbers, cooling towers); however, no zero discharge semiconductor facilities exist in the U.S. to their knowledge (ERG, 2016a). Similarly, NACWA stated that they were not aware of any E&EC zero discharge facilities (U.S. EPA, 2016c).

EPA also performed a targeted literature search and identified several wastewater treatment studies specific to the E&EC industry. For instance, a bench-scale study (Tang, et al., 2006) investigated the removal of PFOS from semiconductor wastewater. As of 2006, PFOS was an essential photolithographic chemical with no chemical substitutes; however, PFOS is toxic, bioaccumulative, and persistent. Tang found PFOS at concentrations of about 1,650 mg/L in semiconductor wastewater generated from developing and wet stripping washes. In many cases, facilities neutralize and send this wastewater to a POTW. However, Tang's study found RO membranes typically removed 99 percent or more of the PFOS from the wastewater over a wide range of influent concentrations (0.5 to 1,500 mg/L). Since the majority of semiconductor facilities use RO membranes for the production of ultrapure water, Tang indicates that the semiconductor industry is familiar with this wastewater treatment technology and could potentially use RO treatment for wastewater containing PFOS.

As mentioned in Section 5.2.2.2, EPA identified another bench-scale study (Sturgill, et al., 2000) that evaluated a new method for recovering and recycling gallium and arsenic from GaAs polishing wastes. GaAs-based semiconductor devices are used in military and commercial applications (e.g., lasers, LEDs). In 2000, the technique for recovery was ferric hydroxide precipitation and filtration, with the resulting wastewater discharged to a POTW or to a surface water and wastes sent to landfills. The newer method, described by Sturgill, involves pH adjustment, centrifugation (sludge to recovery), filtration, ferric hydroxide coprecipitation, and settling with filtration (Sturgill, et al., 2000).

A patented wastewater treatment process, presented at the 2013 International Water Conference, treats wastewater generated by the microelectronics industry. Bench-scale and pilot-scale studies demonstrated the system could treat total organic carbon (TOC), TMAH, and total Kjeldahl nitrogen (TKN). Specifically, the system consists of three stages in series:

- Aerobic biological treatment – an activated sludge aerobically degrades organic nitrogen and organics into ammonia-nitrogen and carbon dioxide.
- Oxidation – an ozonation system chemical oxidizes ammonia into nitrates.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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- Anaerobic biological treatment – an activated sludge anaerobically denitrifies the nitrates into nitrogen gas (Ballard, et al., 2013).

The study indicated this system achieved greater than 98 percent removal of TOC, 99 percent of TMAH, and 95 percent of TKN. As stated above, TMAH is a chemical used in photoresists for newer photolithography processes. TMAH is hazardous because it is toxic, corrosive, slow to biodegrade, and can contribute to eutrophication of water bodies. According to the study author, the patented aerobic/anaerobic biological treatment system with denitrification is a robust and low-cost alternative for wastewater generated at semiconductor and TFT-LCD manufacturing facilities (Ballard, et al., 2013; Infilco Degremont Inc., 2014).

One semiconductor manufacturing facility, Global Foundries East Fishkill Facility in Hopewell Junction, New York, provided specific details on a heavy metal wastewater treatment plant it employs on site (Marone, 2016). The heavy metal wastewater treatment plant consists of calcium hydroxide precipitation (to remove fluoride and other metals), microfiltration, polymer flocculation, an acid/base slurry treatment step, and clarification. In addition, the facility operates an ammonia treatment plant for segregated industrial wastewater streams, where ammonia is removed, distilled, and marketed to another party (Marone, 2016).

To identify additional emerging technologies that are being evaluated and/or implemented by the E&EC industry, EPA reviewed recent literature compiled in the IWTT Database (for more information on the IWTT Database, see Section 6.2 of this report). EPA queried the IWTT Database for treatment of E&EC wastewater, which produced five articles with pollutant removal data (Huang, et al., 2011; K. Kim, et al., 2012; S. Kim, et al., 2011; Mehta, et al., 2014; Ryu, et al., 2008). Table 5-15 presents the parameter effluent concentration and percent removal data for all five articles. All but one of the studies were pilot scale (Ryu, et al., 2008). However, EPA identified two studies that evaluated the performance of traditional chemical precipitation systems used by the industry, and three studies focused on more advanced technologies for the industry, including biological treatment or filtration technologies. In addition, most of the studies evaluated removal efficiency of pollutants that do not currently have E&EC ELGs, including ammonium-nitrogen, TOC, COD, and TMAH (Huang, et al., 2011; K. Kim, et al., 2012; S. Kim, et al., 2011; Mehta, et al., 2014; Ryu, et al., 2008).

5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

**Table 5-15. Summary of Wastewater Treatment Technologies for Electrical and Electronic Components Wastewater**

Wastewater Treatment Technology (Order of Unit Processes)	Treatment Scale	Parameter	Effluent Concentration (mg/L)	Percent Removal	Reference
Anaerobic Suspended Growth, Aerobic Suspended Growth, Clarification, Advanced Oxidation Processes (NEC), Anaerobic Suspended Growth, and Clarification	Pilot	Ammonium-nitrogen (NH <sub>4</sub> -N)	3	78.57%	(Mehta, et al., 2014)
		Chemical oxygen demand	NR	98.00%	
		Nitrogen, Kjeldahl total (TKN)	27	83.64%	
		Tetramethyl ammonium hydroxide (TMAH)	NR	80.00%	
		Total organic carbon (TOC)	NR	98.00%	
Aerobic Suspended Growth, Clarification, Advanced Oxidation Processes (NEC), Anaerobic Suspended Growth, and Clarification	Pilot	Ammonium-nitrogen (NH <sub>4</sub> -N)	6.4	8.57%	
		Nitrogen, Kjeldahl total (TKN)	26	96.53%	
		Tetramethyl ammonium hydroxide (TMAH)	NR	99.00%	
		Total organic carbon (TOC)	NR	98.00%	
Electrocoagulation	Pilot	Copper	NR	95.00%	(K. Kim, et al., 2012)
Chemical Precipitation, Controlled Hydrodynamic Cavitation, and Clarification	Pilot	Calcium	23.4	90.71%	(S. Kim, et al., 2011)
Granular-Media Filtration, Membrane Filtration, and Reverse Osmosis	Pilot	Alkalinity (as CaCO <sub>3</sub> )	< 1.5	> 97.69%	(Huang, et al., 2011)
		Ammonium-nitrogen (NH <sub>4</sub> -N)	1.62	84.57%	
		Chemical oxygen demand	4.9	93.57%	
		Chloride	21.1	92.19%	
		Conductivity	69.2	97.35%	
		Hardness (as CaCO <sub>3</sub> )	< 1.5	> 99.12%	
		Nitrate (as N)	0.73	51.33%	
			0.06	71.43%	
		Silicate (SiO <sub>4</sub> -2 as SiO <sub>2</sub> )	0.98	88.28%	
		Sulfate (as SO <sub>4</sub> )	0.34	99.87%	
		Suspended solids	1	97.50%	
		Total dissolved solids (TDS)	53.5	95.18%	
		Total organic carbon (TOC)	1.3	76.79%	
		Turbidity	0.06	99.80%	
Chemical Precipitation and Clarification	Full	Ammonium-nitrogen (NH <sub>4</sub> -N)	17	88.96%	(Ryu, et al., 2008)

NR – Not Reported

### 5.2.5 *Summary of EPA's Continued Review of the E&EC Category*

As part of the current review, EPA expanded the scope of its review beyond sapphire crystal manufacturing, considered in the 2015 Annual Review, to include the entire E&EC Category. Furthermore, EPA studied the E&EC industry to understand how the industry profile, wastewater discharges, and wastewater treatment have changed since promulgation of the ELGs in 1983. EPA analyzed all four subparts of the 1983 E&EC ELGs, with a specific emphasis on Subpart A, semiconductor manufacturing. EPA evaluated several publicly available data sources including DMR and TRI data, IBISWorld industry market reports, economic census data, and peer-reviewed journal articles (from the literature review and IWTT Database). In addition, EPA contacted facilities, met with SIA, and attended industry conferences (2016 ASMC SEMI conference, 2016 SEMICON West).

From these data collection efforts, EPA learned that the majority of E&EC facilities are indirect dischargers (discharge to POTWs). They have implemented several new process operations using new chemicals and the resulting wastewater characteristics have likely changed over time. Further, the industry may also be phasing out the use of some currently regulated pollutants, including TTO.

Specifically, relating to all four of the existing E&EC subcategories, from this review, EPA learned:

- *Subpart A – Semiconductor Manufacturing.*
  - Over the past 30 years, discharge practices have not changed dramatically. Most semiconductor manufacturing facilities continue to discharge to POTWs. SIA and NACWA members stated they were not aware of any zero discharge semiconductor manufacturing facilities (ERG, 2016a; U.S. EPA, 2016c).
  - EPA did not identify significant changes in the overall semiconductor manufacturing process operation sequence, though semiconductor manufacturers have added updated processes (e.g., plating, CVS, copper metallization, CMP, C4 bump) and increased repetition of the sequence (from up to 20 times in 1983 to 90 times in 2016).
  - EPA confirmed that updated manufacturing processes introduce new pollutants in the wastewater, due to new materials, lithography process chemistries, and advancement of tools required to keep up with rapidly changing technology demands. Most noteworthy of the new pollutants are PFOS and TMAH, which are toxic, persistent, and bioaccumulative (ERG, 2016a; Tang, et al., 2006). NACWA members also expressed concerns with higher concentrations of ammonia, nitrogen, sulfate, fluoride, and copper discharged from E&EC facilities (U.S. EPA, 2016c).
  - EPA's review of wastewater treatment technologies shows that the industry continues to rely on the traditional technologies identified at the time of the 1983 ELG rulemaking. However, the industry is actively evaluating new technologies (e.g., biological, ion exchange, reverse osmosis, electrowinning) and wastewater management practices (e.g., rinse recycle, RO reject recycle) aimed at treating some of the newer pollutants and conserving water.

## 5—EPA's Review of Additional Industrial Categories

## Section 5.2—Electrical and Electronic Components (E&amp;EC) (40 CFR Part 469)

- *Subpart B – Electronic Crystal Manufacturing.*
  - During the 2015 Annual Review, EPA concluded that sapphire crystal manufacturing is a growing sector of the electronic crystal manufacturing industry and that the E&EC ELGs apply to this sector. Though EPA did not specifically focus on electronic crystals manufacturing during this review, at least one source that suggests that GaAs and sapphire crystal manufacturing process steps are similar in nature, and that the manufacturing process operation sequence has not changed substantially since 1983.
  - EPA has not thoroughly investigated the processes, wastewater characteristics, discharges, or treatment associated with existing electronic crystal manufacturing.
- *Subpart C – CRT Manufacturing.*
  - EPA's research indicates that CRTs have mostly been replaced by newer technologies (e.g., LCD, OLED, plasma display) for TV applications. EPA confirmed that the market for electron tube manufacturing has decreased significantly since 1983. In addition, several regulations and other efforts have been established for recycling CRTs, suggesting their accelerated phase out.
  - While EPA has identified replacement technologies for CRTs, EPA has not evaluated current processes, wastewater generation, or treatment technologies.
- *Subpart D – Luminescent Materials Manufacturing.*
  - Luminescent materials consisted of fluorescent lamp phosphors in 1983 (applied, e.g., in TVs, video game displays, and lamps); however, most of these applications have been replaced with newer technologies, such as LEDs.
  - While EPA has identified replacement technologies for luminescent materials, EPA has not evaluated current processes, wastewater generation, or treatment technologies.

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5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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5—EPA's Review of Additional Industrial Categories  
Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)

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*Section 5.2—Electrical and Electronic Components (E&EC) (40 CFR Part 469)*

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*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

### 5.3 Miscellaneous Food and Beverage Sectors

EPA reviewed the miscellaneous food and beverage sectors because they have collectively ranked relatively high in EPA's past toxicity rankings analyses (TRAs). The most recent TRA was completed for the 2015 Annual Review. EPA, however, has not specifically evaluated individual food and beverage sectors and discharges in recent years because most of the toxic discharges have been from a single facility<sup>53</sup> (U.S. EPA, 2016). Table 5-16 lists the miscellaneous food and beverage sectors by Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) codes.

**Table 5-16. Miscellaneous Food and Beverage Sectors**

SIC Code	SIC Description	NAICS Code	NAICS Description
2038	Frozen Specialties, Not Elsewhere Classified	311412	Frozen Specialty Food Manufacturing
2045	Prepared Flour Mixes and Doughs	--	--
2051	Bread and Other Bakery Products, except Cookies and Crackers	--	--
2052	Cookies and Crackers	311821	Cookie and Cracker Manufacturing
2064	Candy and Other Confectionery Products	311352	Confectionery Manufacturing from Purchased Chocolate
2066	Chocolate and Cocoa Products	311351	Chocolate and Confectionery Manufacturing from Cacao Beans
2074	Cottonseed Oil Mills	--	--
2075	Soybean Oil Mills	311224	Soybean and Other Oilseed Processing
2079	Shortening, Table Oils, Margarine, and Other Edible Fats and Oils, Not Elsewhere Classified	311225	Fats and Oils Refining and Blending
2082	Malt Beverages	312120	Breweries
2084	Wines, Brandy, & Brandy Spirits	312130	Wineries
2085	Distilled and Blended Liquors	312140	Distilleries
2086	Bottled and Canned Soft Drinks and Carbonated Water	312111	Soft Drink Manufacturing
2087	Flavoring Extracts and Flavoring Syrups, Not Elsewhere Classified	311930	Flavoring Syrup and Concentrate Manufacturing
2097	Manufactured Ice	--	--
2098	Macaroni, Spaghetti, Vermicelli, and Noodles	--	--
2099	Food Preparations, Not Elsewhere Classified	311340	Nonchocolate Confectionery Manufacturing
		311942	Spice and Extract Manufacturing
		311991	Perishable Prepared Food Manufacturing
		311999	All Other Miscellaneous Food Manufacturing
--	--	311813	Frozen Cakes, Pies, and Other Pastries Manufacturing
--	--	311920	Coffee and Tea Manufacturing

Sources: (ERG, 2016); *DMRLTOutput2015\_F&B\_v1*; *TRILTOutput2015\_F&B\_v1*

<sup>53</sup> As part of the 2015 Annual Review, EPA identified one facility, Bacardi Corporation in Catano, Puerto Rico, that accounted for over 90 percent of the 2013 discharge monitoring report (DMR) toxic-weighted pound equivalent (TWPE) from the miscellaneous food and beverage sectors. EPA confirmed that the discharges met permit limits and resulted from molasses process wastewater used to manufacture rum (U.S. EPA, 2016).

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

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EPA reviewed discharges from the sectors listed in Table 5-16 to identify any discharges that may require further review for potential development of effluent limitations guidelines and standards (ELGs) by conducting the following analyses:

- Reviewed SIC and NAICS codes for facilities reporting information to the Integrated Compliance Information System for the National Pollutant Discharge Elimination System (ICIS-NPDES) and Toxic Release Inventory (TRI), respectively, to ensure that the universe of facilities included in the analysis was representative of all food and beverage processing sectors not currently regulated by ELGs.
- Evaluated total estimated pounds of pollutants, facility counts, and pollutant discharge information in 2015 for miscellaneous food and beverage sectors using discharge monitoring report (DMR) and TRI data.
- For a subset of industry sectors, contacted state and EPA regional NPDES permitting authorities to better understand industry production and treatment characteristics.

Section 5.3.1 provides background on EPA's previous reviews of the miscellaneous food and beverage sectors. Section 5.3.2 summarizes EPA's current review of available pollutant discharge data for the miscellaneous food and beverage sectors. Section 5.3.3 summarizes EPA's further investigation of the distillery and soft drink manufacturing sectors. Section 5.3.4 summarizes this review.

### ***5.3.1 Previous Review of the Miscellaneous Food and Beverage Sectors***

EPA first reviewed miscellaneous food and beverage processing sectors in 1975, and, identified the primary pollutants discharged were conventional pollutants (biochemical oxygen demand (BOD), total suspended solids (TSS), oil and grease, and pH), rather than toxic pollutants (U.S. EPA, 1975a, 1975b). EPA considered establishing ELGs for conventional pollutants from direct discharging facilities in certain sectors, including vegetable oil processing and refining, beverages, bakery and confectionery products, pet foods, and miscellaneous and specialty products. EPA did not consider pretreatment standards for indirect dischargers because it concluded that none of the conventional pollutant constituents would interfere with or pass through publicly owned treatment works (POTWs). EPA, however, did not pursue ELGs for these sectors because it changed the focus of the ELGs program to the control of toxic pollutants shortly after completion of its review (U.S. EPA, 2006).

As part of its 2006 Annual Review, EPA performed a preliminary investigation of facilities in SIC codes 2075 – Soybean Oil Mills, 2083 – Malt Beverages, and 2085 – Distilled and Blended Liquors, to evaluate whether ELGs were warranted for addressing wastewater discharges. Consistent with the 1975 review, discharges from facilities within these sectors mostly discharge conventional pollutants rather than toxic pollutants. Additionally, facilities in these sectors employed onsite biological wastewater treatment or sent wastewater to POTWs to remove conventional pollutants. EPA thus decided not to establish ELGs for these sectors (Bicknell, 2004; U.S. EPA, 2006).

### 5.3.2 Review of Discharge Estimates for the Miscellaneous Food and Beverage Sectors

EPA evaluated the total pounds of pollutants discharged per year as reported in 2015 DMR and TRI data by SIC and NAICS code, as shown in Table 5-17. EPA used 2015 data for its review of the miscellaneous food and beverage sectors because they represented the most recent and complete set of industrial wastewater discharge data available at the time the review began. Specifically, EPA downloaded the 2015 TRI and DMR data from the [Water Pollutant Loading Tool](#) and followed the general quality review steps outlined in Section 2.1.2 to assess their completeness, accuracy, and reasonableness. From the quality review, EPA determined that the 2015 DMR and TRI data were useable for this review. EPA incorporated the DMR and TRI data into a set of static databases, *DMRLTOutput2015\_F&B\_v1* and *TRILTOutput2015\_F&B\_v1*, designed to preserve the integrity of the data and to support subsequent analyses integral to this review. EPA describes these databases below:

- *DMRLTOutput2015\_F&B\_v1* (DCN 08523): 2015 pollutant loadings (pounds per year) for industrial facilities, calculated based on DMR data.
- *TRILTOutput2015\_F&B\_v1* (DCN 08524): 2015 direct and indirect water releases (pounds per year) for industrial facilities.

Although DMR and TRI data are the most comprehensive and readily available source of industrial wastewater discharge data, the data pertain to a subset of actual pollutant discharges. The pollutants and quantities actually discharged are unknown. For instance, DMRs only include data for pollutants with discharge limits or monitoring requirements specified in NPDES permits. Facilities are only required to report pollutant releases to TRI if the releases meet or exceed certain reporting thresholds, and they are only required to report pollutants that are on the TRI Chemicals list. The TRI Chemicals list does not include conventional pollutants such as BOD and TSS. See Section 2.1 of this report for a detailed discussion of the uses and limitations of DMR and TRI data.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

**Table 5-17. DMR and TRI Discharge Estimates for the Miscellaneous Food and Beverage Sectors**

SIC Code	SIC Description	NAICS Code	NAICS Description	DMR Data			TRI Data		
				2015 Total Pounds per Year	Number of Facilities Reporting Pollutant Discharges <sup>a</sup>	Top Pollutants <sup>b</sup>	2015 Total Pounds per Year	Number of Facilities Reporting Pollutant Discharges <sup>a</sup>	Top Pollutants <sup>b</sup>
2038	Frozen Specialties, Not Elsewhere Classified	311412	Frozen Specialty Food Manufacturing	102,000,000	5	TSS	58,500	12	Nitric acid, Ammonia, Nitrate
2085	Distilled and Blended Liquors	312140	Distilleries	50,300,000	32	COD, BOD, TSS, Zinc	4,530	2	Ammonia
2051	Bread and Other Bakery Products, except Cookies and Crackers	--	--	25,200,000	3	TDS	--	--	--
2086	Bottled and Canned Soft Drinks and Carbonated Water	312111	Soft Drink Manufacturing	16,800,000	16	BOD, TSS	23,900	5	Nitrate
2099	Food Preparations, Not Elsewhere Classified	311999	All Other Miscellaneous Food Manufacturing	8,470,000	16	BOD, TDS, TSS, Potassium, Ammonia, Nitrogen	732,000	30	Nitrate, Ammonia, Methanol
		311942	Spice and Extract Manufacturing				108,000	9	Methanol, Ethylene glycol
		311340	Nonchocolate Confectionery Manufacturing				13,400	3	Nitrate, Nitric acid
		311991	Perishable Prepared Food Manufacturing				2,850	1	Nitrate
2082	Malt Beverages	312120	Breweries	6,270,000	10	TSS, BOD, Phosphorus, Ammonia	2,140,000	18	Nitrate
2075	Soybean Oil Mills	311224	Soybean and Other Oilseed Processing	2,970,000	19	COD, BOD, TSS, Oil & Grease	1,550,000	55	Nitrate
2064	Candy and Other Confectionery Products	311352	Confectionery Manufacturing from Purchased Chocolate	450,000	1	COD, BOD	10,500	2	Nitrate
2079	Shortening, Table Oils, Margarine, and Other Edible Fats and Oils, Not Elsewhere Classified	311225	Fats and Oils Refining and Blending	173,000	7	TSS, BOD, Oil & Grease	13,000	3	Methanol

5—EPA's Review of Additional Industrial Categories  
Section 5.3—Miscellaneous Food and Beverage Sectors

**Table 5-17. DMR and TRI Discharge Estimates for the Miscellaneous Food and Beverage Sectors**

SIC Code	SIC Description	NAICS Code	NAICS Description	DMR Data			TRI Data		
				2015 Total Pounds per Year	Number of Facilities Reporting Pollutant Discharges <sup>a</sup>	Top Pollutants <sup>b</sup>	2015 Total Pounds per Year	Number of Facilities Reporting Pollutant Discharges <sup>a</sup>	Top Pollutants <sup>b</sup>
2052	Cookies and Crackers	311821	Cookie and Cracker Manufacturing	111,000	4	TSS, Oil & Grease	967	1	Ammonia
2084	Wines, Brandy, & Brandy Spirits	312130	Wineries	98,200	8	Sodium, TSS, Total Oxygen Demand, BOD	183,000	2	Ammonia
2087	Flavoring Extracts and Flavoring Syrups, Not Elsewhere Classified	311930	Flavoring Syrup and Concentrate Manufacturing	14,800	2	TSS, COD	10,600	5	Ammonia, Nitrate, Methanol
2066	Chocolate and Cocoa Products	311351	Chocolate and Confectionery Manufacturing from Cacao Beans	5,670	1	TSS, BOD, Oil & Grease	2,720	1	Ammonia
2098	Macaroni, Spaghetti, Vermicelli, and Noodles	--	--	2,890	1	TDS	--	--	--
2074	Cottonseed Oil Mills	--	--	2,420	1	BOD, TSS	--	--	--
2097	Manufactured Ice	--	--	239	2	TSS	--	--	--
2045	Prepared Flour Mixes and Doughs	--	--	105	1	TSS, BOD	--	--	--
--	--	311920	Coffee and Tea Manufacturing	--	--	--	9,760	2	Nitrate
--	--	311813	Frozen Cakes, Pies, and Other Pastries Manufacturing	--	--	--	12.6	2	Ethylene glycol, Nitrate
<b>Sum for all Miscellaneous Food and Beverage Sectors</b>				<b>213,000,000</b>	<b>129</b>	<b>--</b>	<b>4,870,000</b>	<b>153</b>	<b>--</b>

Source: (ERG, 2016); *DMRLTOutput2015\_F&B\_v1*; *TRILTOutput2015\_F&B\_v1*

TSS: total suspended solids; COD: chemical oxygen demand; BOD: biochemical oxygen demand; TDS: total dissolved solids

<sup>a</sup> Number of facilities with pounds per year greater than zero.

<sup>b</sup> Top pollutants are the pollutants that collectively account for 95 percent or more of the total pollutant loads from facilities in each NAICS or SIC code.

### 5.3.3 Further Investigation of the Distillery and Soft Drink Manufacturing Sectors

Based on review of the DMR data summarized in Table 5-17, EPA selected Distilled and Blended Liquors (distilleries) (SIC Code 2085, NAICS Code 312140) and Bottled and Canned Soft Drinks and Carbonated Water (soft drink manufacturers) (SIC Code 2086, NAICS Code 312111) for further investigation because they ranked high relative to other sectors in terms of discharge amounts and number of facilities. EPA primarily relied on the DMR data in prioritizing the sectors for further investigation because the data are more comprehensive with respect to conventional pollutants, which have historically been associated with wastewater from food and beverage manufacturing sectors. See Section 2.1 of this report for a detailed discussion of the uses and limitations of TRI data.

#### 5.3.3.1 Facility Counts for Distilleries and Soft Drink Manufacturers

To better understand the number and distribution of distilleries and soft drink manufacturers across the U.S., EPA also reviewed 2012 U.S. Census data to identify the number of facilities by state (U.S. Census, 2012). The U.S. Census provides the most complete available estimates of the number of industrial facilities in the U.S. As shown in Table 5-18, there are 458 soft drink manufacturers according to the U.S. Census, but only 16 facilities with DMR data and 5 facilities with TRI data. The discrepancy in facility counts is primarily due to DMR and TRI reporting requirements. For example, facilities are not required to submit DMR data for indirect discharges, so sectors with high numbers of facilities in the U.S. Census data may indicate facilities discharging indirectly to POTWs.

**Table 5-18. States with Distilleries and Soft Drink Manufacturers**

State	Distilleries			Soft Drink Manufacturers		
	Number of Establishments in Census Data (2012)	DMR Facilities (2015)	TRI Facilities (2015)	Number of Establishments in Census Data (2012)	DMR Facilities (2015)	TRI Facilities (2015)
Alabama	1	0	0	5	1	0
Alaska	2	0	0	1	0	0
Arizona	0	0	0	8	0	0
Arkansas	3	0	0	3	1	0
California	21	0	0	67	0	0
Colorado	18	0	0	7	0	0
Connecticut	2	0	0	9	0	0
Florida	8	1	0	27	0	1
Georgia	1	0	0	15	0	1
Hawaii	4	0	0	7	0	0
Idaho	3	0	0	3	0	0
Illinois	7	1	1	12	1	0
Indiana	2	2	0	8	1	1
Iowa	5	0	0	4	1	0
Kansas	2	5 <sup>a</sup>	0	3	0	0
Kentucky	19	17	0	6	6	0
Louisiana	4	0	0	3	0	0
Maine	4	0	0	0	0	0
Maryland	3	0	0	8	0	0
Massachusetts	5	0	0	8	1	1

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

**Table 5-18. States with Distilleries and Soft Drink Manufacturers**

State	Distilleries			Soft Drink Manufacturers		
	Number of Establishments in Census Data (2012)	DMR Facilities (2015)	TRI Facilities (2015)	Number of Establishments in Census Data (2012)	DMR Facilities (2015)	TRI Facilities (2015)
Michigan	5	0	0	11	1	0
Minnesota	3	0	0	9	0	0
Mississippi	0	0	0	2	0	0
Missouri	4	1	1	9	0	0
Montana	6	0	0	4	0	0
Nebraska	0	1 <sup>a</sup>	0	3	1	0
Nevada	2	0	0	3	0	0
New Hampshire	0	0	0	1	0	0
New Jersey	3	0	0	18	0	0
New Mexico	2	0	0	2	0	0
New York	13	0	0	31	0	0
North Carolina	6	0	0	14	0	0
North Dakota	0	0	0	1	0	0
Ohio	8	0	0	15	1	0
Oklahoma	0	0	0	7	0	0
Oregon	17	0	0	5	0	0
Pennsylvania	5	0	0	20	0	0
Rhode Island	1	0	0	3	0	0
South Carolina	2	0	0	4	0	0
South Dakota	0	0	0	1	0	0
Tennessee	6	2	0	13	1	0
Texas	17	0	0	36	0	1
Utah	2	0	0	6	0	0
Vermont	3	0	0	0	0	0
Virginia	4	0	0	10	0	0
Washington	17	0	0	11	0	0
West Virginia	3	0	0	1	0	0
Wisconsin	6	0	0	12	0	0
Wyoming	2	0	0	2	0	0
Virgin Islands <sup>b</sup>	-	1	0	-	0	0
Puerto Rico <sup>b</sup>	-	1	0	-	0	0
<b>Total</b>	<b>251</b>	<b>32</b>	<b>2</b>	<b>458</b>	<b>16</b>	<b>5</b>

Sources: (U.S. Census, 2012); DMRLTOutput2015\_F&B\_v1; TRILTOutput2015\_F&B\_v1

<sup>a</sup> U.S. Census data and DMR and TRI data are for different years (2012 and 2015, respectively).

<sup>b</sup> Industry data are not available for the Virgin Islands or Puerto Rico in the 2012 U.S. Census.

### 5.3.3.2 Top Pollutants Discharged by Distilleries and Soft Drink Manufacturers

EPA evaluated the facilities and pollutants contributing to the majority of the total pollutant loads in the distillery and soft drink manufacturing sectors as shown in Table 5-19 and Table 5-20. For this review, EPA defined the top pollutants as those that collectively account for 95 percent or more of the total pollutant discharges from facilities in a sector. Among distilleries, the top DMR pollutants were chemical oxygen demand (COD), BOD, TSS, zinc, chloride, oil and grease, and phosphorus. Ammonia accounted for 99 percent of discharges reported to TRI by

5—EPA's Review of Additional Industrial Categories  
Section 5.3—Miscellaneous Food and Beverage Sectors

distilleries. The data demonstrate that, with the exception of BOD, the top pollutants reported to DMR and TRI from distilleries are discharged by one, or possibly two, facilities.

The top DMR pollutants discharged by soft drink manufacturers included BOD, TSS, total filterable residue, and chloride. Nitrate compounds were the top TRI pollutant discharged by soft drink manufacturing facilities. The data demonstrates that the top pollutants as reported to DMR and TRI from soft drink manufacturing facilities are discharged from one or two facilities.

**Table 5-19. Pollutants Estimated to be Discharged in the Highest Amounts in 2015 by the Distillery Sector**

Pollutant	Total Pounds	Facilities Reporting Discharge	Facility Location	Facility Percent of Total Sector Pounds
<b>2015 DMR Data</b>				
COD	38,000,000	Virgin Islands Rum Industries	Frederiksted, VI	99.9%
BOD	5,050,000	Bacardi Corp	San Juan, PR	94.5%
		Illinois Corn Processing LLC	Pekin, IL	1.80%
		Campari America	Lawrenceburg, KY	1.19%
		MGP Ingredients Inc.	Atchison, KS	1.17%
		Jim Bean Brands Co. <sup>a</sup>	Frankfort, KY	0.95%
TSS	3,440,000	Virgin Islands Rum Industries	Frederiksted, VI	61.8%
		Woodford Reserve Distillery <sup>a</sup>	Versailles, KY	19.0%
Zinc	1,320,000	Woodford Reserve Distillery <sup>a</sup>	Versailles, KY	99.9%
Chloride	761,000	MGP Ingredients Inc	Atchison, KS	73.2%
Oil and Grease	727,000	Woodford Reserve Distillery <sup>a</sup>	Versailles, KY	89.9%
Phosphorus	469,000	MGP Ingredients Inc.	Atchison, KS	97.9%
<b>2015 TRI Data</b>				
Ammonia	4,500	Illinois Corn Processing LLC	Pekin, IL	99.4%

Source: (ERG, 2016); *DMRLTOutput2015\_F&B\_v1*; *TRIOutput2015\_F&B\_v1*

TSS: total suspended solids; COD: chemical oxygen demand; BOD: biochemical oxygen demand

<sup>a</sup> Facility identified as having potential data errors, described in Table 5-21.

**Table 5-20. Pollutants Estimated to be Discharged in the Highest Amounts in 2015 by the Soft Drink Manufacturing Sector**

Pollutant	Total Pounds	Facilities Reporting Discharge	Facility Location	Facility Percent of Total Sector Pounds
<b>2015 DMR Data</b>				
BOD	15,200,000	Wis Pak of Norfolk Incorporated	Norfolk, NE	99.9%
TSS	1,500,000	Wis Pak of Norfolk Incorporated	Norfolk, NE	79.9%
		Pepsi Cola Bottling Co.	Corbin, KY	18.8%
Total Filterable Residue (dried at 105°C)	63,000	G&J Pepsi Cola Bottling Co.	Franklin Furnace, OH	100%
Chloride	44,600	Pepsi Cola Bottling Co.	Austin, IN	56.1%
		Nestle Water North America, Inc.	Red Boiling Springs, TN	43.9%

5—EPA's Review of Additional Industrial Categories  
Section 5.3—Miscellaneous Food and Beverage Sectors

**Table 5-20. Pollutants Estimated to be Discharged in the Highest Amounts in 2015 by the Soft Drink Manufacturing Sector**

Pollutant	Total Pounds	Facilities Reporting Discharge	Facility Location	Facility Percent of Total Sector Pounds
<b>2015 TRI Data</b>				
Nitrate Compounds	22,700	Coca-Cola Refreshments	Northampton, MA	60.7%
		Coca-Cola North America – Waco Plant	Waco, TX	34.8%

Source: (ERG, 2016); *DMRLTOutput2015\_F&B\_v1*; *TRILTOutput2015\_F&B\_v1*

TSS: total suspended solids; BOD: biochemical oxygen demand

### 5.3.3.3 Review of the Accuracy of DMR Data for the Distillery and Soft Drink Manufacturing Sectors

EPA reviewed the accuracy of the DMR data for distillery and soft drink manufacturing facilities responsible for the high loads of the top pollutants in their sectors. EPA examined facility discharge flows and pollutant concentrations to evaluate if they were similar from month to month, because unusually high or low values may indicate potential reporting errors. EPA identified five facilities with potential data errors, as shown in Table 5-21. EPA then discussed the accuracy of the data with NPDES permitting authorities, as discussed below in Section 5.3.3.4.

**Table 5-21. Facilities with Potential Data Errors**

Facility Name & Location (NPDES ID)	Review Results
<b>Distilleries</b>	
Campari America, Lawrenceburg, KY (KY0001643)	EPA identified potential unit errors for BOD quantities from outfall 002; January, February, March, and October 2015 BOD quantities were two orders of magnitude ( $10^2 \times$ ) larger than other months.
Jim Beam Brands Co., Frankfort, KY (KY0001252)	EPA identified a potential unit error for a flow value from outfall 002; the December 2015 flow value was three orders of magnitude ( $10^3 \times$ ) larger than other months.
Woodford Reserve Distillery, Versailles, KY (KY0102261)	EPA identified potential unit errors for flow values from outfall 001; July and August 2015 flow values were six orders of magnitude ( $10^6 \times$ ) higher than other months.
<b>Soft Drink Manufacturers</b>	
Pepsi Cola Bottling Co., Corbin, KY (KYR003303)	EPA identified potential unit errors for flow values from outfall 001, 002, 003, and 004; December 2015 flow values were two orders of magnitude ( $10^2 \times$ ) higher than other months.
Wis Pak, Norfolk, NE (NE0131059)	EPA identified potential unit errors for flow values from outfall 001; March and June 2015 flow values were two orders of magnitude ( $10^2 \times$ ) larger than other months.

Source: *DMRLTOutput2015\_v1*

#### 5.3.3.4 Follow Up with NPDES Permitting Authorities

To gather more information on the operations and discharges from facilities in Table 5-21, EPA contacted EPA Region 2, the California State Water Resources Control Board, Illinois EPA, the Kansas Department of Health and Environment, the Kentucky Energy and Environment Cabinet, the Nebraska Department of Environmental Protection, and the Ohio EPA. EPA obtained copies of facility permits and gathered information on process operations, wastewater characteristics, and current wastewater treatment practices for the distillery and soft drink manufacturing sectors.

##### *Follow-up with NPDES Permitting Authorities Concerning Distilleries*

EPA Region 2 confirmed that the DMR data were accurate for the two distilleries in the Virgin Islands and Puerto Rico. EPA also contacted state NPDES permitting authorities concerning the six distilleries in Illinois, Kansas, and Kentucky identified in Table 5-19, and confirmed that the DMR data were accurate. State NPDES permitting authorities stated that relatively high discharges of BOD, TSS, and oil and grease at four of the distilleries, and zinc at one of the distilleries, result from non-process wastewater, including non-contact stormwater or commingled sanitary wastewater. At three other distilleries, NPDES permitting authorities confirmed that process wastewater contributes to the relatively high BOD, COD, TSS, chloride, and phosphorus discharges identified by this review.

As shown in Table 5-19, zinc is the only top pollutant reported by distilleries in 2015 that is a toxic pollutant. EPA confirmed that zinc is only discharged by one facility in Kentucky and originates from stormwater rather than process wastewater. NPDES permitting authorities did not identify additional pollutants discharged from distilleries that are of concern. Information provided by NPDES permitting authorities is summarized in Table 5-22.

NPDES permitting authorities also told EPA how two distilleries are working to reduce their discharges. MGP Ingredients, Inc. in Kansas is conducting a pilot treatment study in accordance with the state's nutrient reduction policy. The Cruzan Rum Distillery in the Virgin Islands recently installed a new Condensed Molasses Soluble evaporative process plant that will significantly reduce BOD, COD, and TSS discharges.

EPA also contacted the California State Water Resources Control Board to identify why none of the 21 distilleries in California, as shown in Table 5-18, reported DMR or TRI data for 2015. EPA identified that distilleries in California indirectly discharge their process wastewater to POTWs. As noted above in Section 5.3.3, facilities are not required to report discharges of conventional pollutants to TRI, nor are they required to report DMR data concerning indirect discharges.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

**Table 5-22. Summary of Follow-up with NPDES Permitting Authorities Concerning Distilleries**

State	Facility Name and Location (NPDES ID)	Top Pollutants Discharged by Facilities	Primary Source of Pollutant at Outfall <sup>a</sup>	Description of Information Gathered from State/Region	Reference(s)
California	No specific facilities identified	NA	NA	State contact confirmed that all distilleries in California discharge to POTWs.	(Vazquez, 2017)
Kentucky	Jim Beam Brands, Frankfort, KY (KY0001252)	BOD	Stormwater	Facility does not directly discharge process wastewater. High BOD loadings at outfall due to stormwater.	(KY DEP, 2013a)
	United Distillers, Owensboro, KY (KY0001031)	TSS	Stormwater	Facility does not directly discharge process wastewater. High TSS loadings at outfall due to stormwater.	(KY DEP, 2016a)
	Campari America, Lawrenceburg, KY (KY0001643)	BOD	Sanitary effluent	The facility discharges process wastewater combined with sanitary wastewater through one outfall. The facility's permit presents concentration-based BOD limits but notes that they only need to be applied when the sanitary wastewater makes up 100 percent of the discharge.	(KY DEP, 2015)
	Woodford Reserve Distillery, Versailles, KY (KY0102261)	Oil & grease, zinc, TSS	Stormwater	Facility does not directly discharge process wastewater. State contact stated that high oil & grease, zinc, and TSS discharges are due to stormwater runoff. Zinc is a common pollutant in Kentucky's industrial stormwater. Exact source of zinc in facility's runoff is unknown, but may have been due to roofing materials.	(Becker, 2017; KY DEP, 2016b)
Kansas	MGP Ingredients Inc., Atchison, KS (KS0100269)	BOD, chloride, phosphorus	Wheat starch and gluten process wastewater; ferric chloride; phosphoric acid	Facility combines ethanol process wastewater with wheat starch and gluten process wastewater. The wastewater is sent to a conditioning tank, anaerobic digester, aeration basin, and clarifier prior to discharge. To allow for effective treatment, the facility adds ammonia nitrogen and phosphoric acid to the wastewater in the conditioning tank and ferric chloride and micro-nutrients (copper, cobalt, nickel, aluminum) to the anaerobic digester. Even with added nutrients, the wheat component of the process wastewater is not readily amenable to biological reduction, so the effluent BOD concentration remains high. According to the state contact, the facility is working with permitting authorities to conduct a pilot study on nutrient reduction practices specifically for phosphorus, in accordance with the state nutrient reduction policy. The study is not specifically targeting BOD removal.	(Carlson, 2017; KS DHE, 2011)

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

**Table 5-22. Summary of Follow-up with NPDES Permitting Authorities Concerning Distilleries**

State	Facility Name and Location (NPDES ID)	Top Pollutants Discharged by Facilities	Primary Source of Pollutant at Outfall <sup>a</sup>	Description of Information Gathered from State/Region	Reference(s)
Illinois	Illinois Corn Processing LLC, Pekin, IL (IL0002909)	BOD, TSS	Process wastewater	Facility makes both beverage- and fuel-grade ethanol. The BOD and TSS quantities did not exceed permit limits. The IL EPA is in the process of reissuing a new permit for this facility and is providing a copy to EPA.	(LeCrone, 2017)
Region 2	Virgin Islands Rum Industries, Cruzan Rum Distillery, Frederiksted, VI (VI0020052)	COD, TSS	Process wastewater	Facility previously discharged fermenter bottoms, seed-tank cleanings, fermenter-tank cleanings, and floor washings via Outfall 001. However, the facility completed construction of a condensed molasses solubles plant to reduce COD, BOD, and TSS loadings through an evaporative separation process. The EPA Region 2 permitting authority indicated that two other distilleries in the Virgin Islands operate as zero discharge facilities, including Diageo in Christiansted.	(Latner, 2017; U.S. V.I. DPNR, 2016)
	Bacardi Corp., San Juan, PR (PR0000591)	BOD	Adjacent wastewater treatment plant effluent	The permitted discharge from the facility is commingled with permitted discharges from two adjacent POTWs and discharged to the ocean via a single outfall. The POTWs have separate NPDES permits and were granted a modification that allows higher permit limits than secondary treatment requirements under Section 301(h) of the Clean Water Act. Permit limits for BOD and TSS for the POTWs and the facility are based on water quality criteria and remain high due to the large mixing zones at the joint ocean outfall.	(Latner, 2017)

NA: Not applicable.

TSS: total suspended solids; COD: chemical oxygen demand; BOD: biochemical oxygen demand

<sup>a</sup> EPA identified the primary source of the pollutant at the outfall from the state/region contact or the facility permit and fact sheet.

***Follow-up with NPDES Permitting Authorities Concerning Soft Drink Manufacturers***

EPA contacted NPDES permitting authorities concerning three facilities in Kentucky, Nebraska, and Ohio, identified in Table 5-20. One of the three facilities discharges only non-process wastewater such as non-contact stormwater. A second facility has an NPDES permit, but discharges process wastewater to a POTW. The only water that the third facility discharges directly to surface waters is reverse osmosis reject water; it discharges all its process wastewater to a POTW. The reject water is produced when source water is treated before its use in manufacturing. Information provided by NPDES permitting authorities is summarized in Table 5-23. As with distilleries, California confirmed that soft drink manufacturers in the state indirectly discharge their process wastewater to POTWs.

*5—EPA's Review of Additional Industrial Categories*  
*Section 5.3—Miscellaneous Food and Beverage Sectors*

**Table 5-23. Summary of Follow-up with NPDES Permitting Authorities Concerning Soft Drink Manufacturers**

State	Facility Name and Location (NPDES ID)	Top Pollutants Discharged by Facilities	Primary Source of Pollutant at Outfall <sup>a</sup>	Description of Information Gathered from State/Region	Reference(s)
California	No specific facilities identified	NA	NA	State contact confirmed no NPDES-permitted soft drink manufacturers exist in California. Soft drink manufacturers in the state discharge to POTWs.	(Vazquez, 2017)
Kentucky	Pepsi Cola Bottling Co., Corbin, KY (KYR003303)	TSS	Stormwater	Permit revealed that four outfalls with high TSS discharges in 2015 discharged stormwater only. State contact noted that the facility is covered under Kentucky's Industrial Stormwater General Permit for Other Facilities.	(KY DEP, 2013b)
Ohio	G&J Pepsi Cola Bottling Co., Franklin Furnace, OH (OH0135267)	Total filterable residue	Reverse osmosis reject water	The facility directly discharges reverse osmosis reject water to surface water at Outfall 001 where they report high discharges of total filterable residue. The state contact confirmed that the facility is required to report total filterable residue, not TDS. All other process wastewater is discharged indirectly to a POTW through a separate outfall.	(Nygaard, 2017)
Nebraska	Wis Pak, Norfolk, NE (NE0131059)	BOD, TSS	Indirect discharge <sup>b</sup>	NE DEQ confirmed that although the facility has a NPDES permit, they discharge process wastewater through Outfall 001 (which had high BOD and TSS loadings in 2015) indirectly to a POTW. EPA recommends that the discharge data for Outfall 001 be excluded from the soft drink manufacturers review.	(Anderson, 2017; NE DEQ, 2015)

NA: Not applicable.

TSS: total suspended solids; BOD: biochemical oxygen demand

<sup>a</sup> EPA identified the primary source of the pollutant at the outfall from the state/region contact or the facility permit and fact sheet.

<sup>b</sup> The facility reported BOD and TSS loadings at an outfall on their 2015 DMR, but the state contact confirmed that the process wastewater through this outfall is indirectly discharged.

### 5.3.4 Summary of EPA's Review of Miscellaneous Food and Beverage Sectors

Through this review, EPA learned:

- Over 92 percent of distilleries and soft drink manufacturers (654 of 709, as shown in Table 5-18) in the study period did not report discharges to DMR or TRI.
- Conventional pollutants such as BOD, TSS, and oil and grease continue to be the top pollutants discharged directly to process wastewaters from distilleries and soft drink manufacturers.
- Based on a review of selected facilities, non-process wastewaters, such as sanitary effluent and stormwater, often are the sources of pollutant discharges reported on DMRs.
- Many of the top pollutants discharged by distilleries and soft drink manufacturers are conventional pollutants, therefore, EPA did not follow up on reported indirect discharges (which go to POTWs) because POTWs are designed to treat conventional pollutants.

### 5.3.5 References

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5—EPA's Review of Additional Industrial Categories  
Section 5.3—Miscellaneous Food and Beverage Sectors

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5—EPA's Review of Additional Industrial Categories  
Section 5.3—Miscellaneous Food and Beverage Sectors

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*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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## **6. EPA’S CONTINUED INVESTIGATIONS OF POLLUTANTS AND TREATMENT TECHNOLOGIES**

EPA continued several ongoing investigations identified in the *Final 2014 Effluent Guidelines Program Plan* (EPA-HQ-OW-2014-0170-0210) and is presenting its current evaluations as part of this review. Specifically, EPA continued its (1) investigation of the manufacture and processing of engineered nanomaterials (ENMs) as a potential new source of industrial wastewater discharge; (2) review of relevant literature documenting the performance of new and improved industrial wastewater treatment technologies for inclusion in its Industrial Wastewater Treatment Technology (IWTT) Database, to be used in future annual reviews; and (3) targeted review of pesticide active ingredient (PAI) discharges from pesticide manufacturing that are not currently regulated under the Pesticide Chemicals ELGs.

EPA documented the quality of the data supporting its review of these industrial categories, analyzed how the data could be used to characterize the industrial wastewater discharges, and prioritized the evaluations for further review. See Appendix A of this report for more information on data usability and the quality of the data sources supporting these reviews.

Sections 6.1, 6.2, and 6.3 of this report provide details of EPA’s continued investigations into ENMs, industrial wastewater treatment technologies, and pesticide chemicals, respectively.

### **6.1 Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater**

Nanomaterials are generally defined as engineered or naturally occurring materials composed of primary particles, with sizes on the order of 1 to 100 nanometers (nm) in at least one dimension, that show physical, chemical, and biological properties not found in bulk samples of the same material (U.S. EPA, 2011). These primary particles, termed nanoparticles, may exhibit novel, size-dependent characteristics, such as increased strength, chemical reactivity, and conductivity, due to their high surface area-to-volume ratio (Gavankar, et al., 2012). Engineered nanomaterials (ENMs) are designed to serve a particular purpose and, as opposed to naturally occurring nanoscale materials, represent a new or additional input to the environment.

In its *Final 2010 Effluent Guidelines Program Plan*, EPA solicited data and information for future annual reviews on the manufacture, use, and environmental release of silver nanomaterials, due to their anti-microbial activity and potential to create a source of silver in associated industrial wastewater discharges (U.S. EPA, 2011). Several commenters indicated that EPA should investigate the impact of nanosilver; a few indicated that EPA should investigate all nanomaterials (U.S. EPA, 2013). In response, EPA began evaluating ENMs as a potential emerging industrial wastewater pollutant category as part of its 2014 Annual Review (U.S. EPA, 2015a).

In the 2014 Annual Review, EPA focused its evaluation of the potential presence and impact of ENMs in industrial wastewater on three classes of ENMs: silver, titanium dioxide, and carbon-based nanomaterials. At the time, these compounds were widely produced and more fully characterized than other types of ENMs. From its review, EPA learned that ENM manufacturing and processing spans multiple industrial sectors (e.g., organic chemicals, plastics, and synthetic fibers (OCPSF) manufacturing, metal finishing, textiles, biomedical applications, and other consumer products), but identified little progress to date to quantify production volumes. Some

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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ENM manufacturing and processing methods likely generate wastewater, but the quantity generated and waste management practices are not documented. In addition, research has shown that common treatment technologies employed at municipal wastewater treatment plants can remove nanomaterials from the wastewater, but that these may then accumulate in the sludge. Further, EPA has not approved any standardized methods for sampling, detecting, or quantifying nanomaterials in aqueous media, though methods for detecting and characterizing nanomaterials in complex media, like industrial wastewater, are under development. EPA concluded that ENMs present a challenge for environmental monitoring, risk assessment, and regulation due to their small size, unique properties, and complexity (U.S. EPA, 2015a). Specifically, in the *Final 2014 Effluent Guidelines Program Plan*, EPA identified several areas for further research necessary to better assess the potential presence and hazard of ENMs in industrial wastewater (U.S. EPA, 2015b). These research activities include:

- Identifying the universe of ENM facilities, their production quantities, and the waste generated and disposed of during the manufacturing and processing of ENMs.
- Developing standard methods and sampling techniques to detect and characterize nanomaterials in industrial wastewater.
- Evaluating and characterizing the fate, transformation, and treatment of ENMs in industrial wastewaters.

As part of the current review, EPA continued its review of ENMs, focusing on new data and information available since the 2014 Annual Review. Although EPA focused on three classes of ENMs in its 2014 Annual Review, EPA did not limit its current review to only these ENMs, as the types of ENMs are evolving. The following sections provide an overview of ongoing efforts related to the relevant areas of research identified in the 2014 Annual Review, as well as research topics and trends being coordinated through the National Nanotechnology Initiative (NNI).<sup>54</sup> Section 6.1.1 presents EPA’s current review ENM research methodology. Section 6.1.2 provides an update on research and information coordinated through NNI. Sections 6.1.3 through 6.1.5 summarize the current status of information related to the areas identified for further research.

### **6.1.1 Research Methodology**

For the current review, EPA attended several workshops and conferences to gather updated information to inform the status of the areas for further research identified above. These workshops and conferences included:

- **QEEN Workshop: Quantifying Exposure to Engineered Nanomaterials (QEEN) from Manufacturing Products in Arlington, Virginia.** Sponsored by the Consumer Product Safety Commission (CPSC) in collaboration with the NNI. This workshop hosted governmental and nongovernmental organizations and experts to discuss current research on quantifying exposure at different stages of the ENMs life cycle and development of characterization tools and techniques. This workshop highlighted

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<sup>54</sup> NNI is a collaborative, interagency U.S. government research and development initiative that provides a framework for individual and cooperative nanotechnology-related activities for 20 federal department and agency units, including EPA.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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current and planned nanomaterial environmental, health, and safety research and the quantitative exposure assessments needed for responsible development of nanotechnology (CPSC, 2016).

- **NNI Strategic Planning Stakeholder Workshop in Washington, D.C.** Sponsored by the NNI, the goal of this workshop was to obtain input regarding the vision for the NNI and comments on key aspects of the 2016 NNI Strategic Plan (NNI, 2016) (see Section 6.1.2 for more information on the NNI Strategic Plan). EPA attended the workshop to gather new information related to research about ENMs, particularly as it related to characterizing and quantifying their presence in industrial wastewater discharge and understanding potential impacts.
- **2016 TechConnect World Innovation Conference & Expo in Washington, D.C.** Sponsored by TechConnect, a global technology outreach and development organization, the conference focused on trends in U.S. and international ENM technology, product development, commercialization, and investment opportunities (TechConnect, 2016). EPA attended this conference to understand current trends and future innovations related to production and use of ENMs.

As part of the continued review of ENMs, EPA also reviewed related and more recently published literature and research from workshop and conference participants, generally published since 2014, including new information published by NNI. EPA's ENM literature review was consistent with the ENM research methodology outlined in Section 6.1.1 of the 2014 Annual Review (U.S. EPA, 2015a). The literature sources include government publications and peer-reviewed journals, identified through internet search engines, such as American Chemical Society Publications and Google Scholar. Appendix A of this report provides information on data usability and the quality of data sources supporting this review.

### **6.1.2 The National Nanotechnology Initiative (NNI)**

The NNI is a collaborative, U.S. government interagency research and development initiative. The NNI expedites the discovery, development, and deployment of nanoscale science and technology to serve the public good; this is accomplished through a program of coordinated research and development aligned with the missions of the participating agencies (NNI, 2016). NNI agencies and academic research centers coordinate research that may facilitate EPA's understanding of the potential for wastewater discharges from ENMs manufacturing and processing, as well as potential impacts on the environment.

In 2016, the NNI released their updated strategic plan for nanotechnology research and development. The plan centers on four goals: (1) advance a world-class technology research and development program; (2) foster the transfer of new technologies into products for commercial and public benefit; (3) develop and sustain educational resources, a skilled workforce, and a dynamic infrastructure and toolset to advance nanotechnology; and (4) support responsible development of nanotechnology (NNI, 2016).

In addition to the four goals released in the NNI 2016 Strategic Plan, NNI's environmental health and safety (EHS) strategic planning and trends in research will focus on five core categories: 1) nanomaterial measurement infrastructure; 2) human exposure

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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assessment; 3) human health; 4) environment; and 5) risk assessment and risk management (NNI, 2011, 2016). As highlighted during the 2016 NNI Strategic Planning Stakeholder Workshop EHS research topics expected to trend over the next decade will include (NNI, 2016):

- Classification of ENMs by function and risk
- Measurement and detection tools
- Safety by design<sup>55</sup>
- Exposure and risk research using relevant exposure scenarios
- Chronic low dose studies of potential impacts on human health and the environment

The goals laid out in the NNI 2016 Strategic Plan, the fourth goal in particular, in addition to the EHS research topics expected to trend over the next decade, will likely address many of EPA's data gaps.

### ***6.1.3 ENM Facility Universe, Production Quantities, and Wastewater Generation***

Between 2006 and 2016, the Project on Emerging Nanotechnologies, a nanotechnology consumer products inventory compiled by the Woodrow Wilson International Center for Scholars and the Virginia Tech Center for Sustainable Nanotechnology, observed an 860 percent increase in the number of consumer products containing ENMs, representing a jump from 212 to 1,827 individual products (Project on Emerging Nanotechnologies, 2016; Roth, et al., 2015). Research continues to suggest that ENMs are used in a wide range of industrial applications and domestic products, including pharmaceuticals, paints, coatings, clothing, electronics, automotive applications, solar panel applications, pigments, and cosmetics (Judy, et al., 2015; Keller & Lazareva, 2014; Sun, et al., 2014).

Despite the variety of industries and applications that use or incorporate ENMs, EPA identified little detailed research regarding the potential presence of ENMs in aqueous waste streams or discharges from industrial activities. However, ENM use in the electronics industry seems to be one area of focus. EPA identified several studies evaluating ENM use within and wastewater generated from the electronics industry, specifically related to chemical mechanical planarization (CMP). CMP, a process that uses abrasive materials (including nanomaterials, such as ceria (CeO<sub>2</sub>) and diamond nanoparticles) to thin, smooth, or polish surfaces, is used extensively for microelectronics manufacturing (Atiquzzaman, 2012).

CMP typically uses either a slurry or a fixed abrasive to polish electrical component surfaces. Both polishing methods rely on mechanical forces and chemical reactions to clean and remove excess material from the electrical component surface being polished. For the slurry method, a mixture of abrasive particles and chemical additives are placed on a polishing pad on a rotating plate. The fixed abrasive method is similar except that the abrasive is bonded to the polishing pad (Zazzera, et al., 2014).

Two case studies demonstrate that ENMs are present in wastewater generated from specific electronics manufacturing processes. Researchers at 3M Company compared ceria nanoparticle concentrations found in wastewater generated by slurry and fixed abrasive CMP and

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<sup>55</sup> A concept that encourages assessment and minimization of health and safety risks during product design.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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concluded that fixed abrasive CMP resulted in significantly lower concentrations of ceria nanoparticles released to wastewater than from slurry CMP. Using the slurry method, in which the nanoparticles are more mobile within the medium, the average mass of nanoparticles released per hour was approximately 30 times higher than the mass released from the fixed abrasive method (Zazzera, et al., 2014). This study demonstrates that ENMs, specifically ceria, are used in electronics polishing, are released to wastewater, and that the quantity released may be dependent upon the polishing method employed.

Researchers at SUNY Polytechnic Institute investigated the fate of nanoparticles from CMP wastewater at a semiconductor manufacturing facility through sampling at the facility's on-site wastewater treatment system. Samples were taken at multiple points throughout the treatment process and analyzed for the presence of nanomaterials using a scanning electron microscopy (SEM) technique with an energy-dispersive X-ray spectroscopy (EDX) detector. Nanomaterials were characterized as nearly-spherical, having a mean diameter of 54 nm, and containing the elements carbon, oxygen, silicon, and aluminum (although the study did not identify their origin (i.e., from CMP slurry or generated incidentally from an industrial process)). Results showed that nanoparticles in CMP wastewater may be captured incidentally by the conventional treatment system filters (two filters with 5 and 15  $\mu\text{m}$  pore sizes, respectively), but the system was unequipped to specifically target removal of nanoparticles based on particle size (Roth, et al., 2015).

Nanoparticles were detected just prior to the point of discharge. In addition, the wastewater from this system was sent to a publicly owned treatment work (POTW) for further treatment. Researchers have expressed concern that ENMs may impact the biota integral to biological treatment processes, potentially reducing biological treatment performance (Roth, et al., 2015; Westerhoff, et al., 2013). The SUNY Polytechnic Institute study demonstrates that nanomaterials are present in wastewater discharges from the electronics industry and suggests that conventional treatment systems can effectively remove ENMs; however, further research may be needed to identify any correlation between nanoparticle size and removal rates.

Though limited data are available related to other industries that may manufacture, process, or use ENMs, EPA is in the process of gathering information about nanoscale materials through a final rule promulgated under the Toxic Substances Control Act (TSCA) section 8(a) (82 FR 3641). Effective August 14, 2017, the rule requires one-time reporting of chemical, manufacturing, and release information by manufacturers and processors of nanoscale materials. Within this rule, nanoscale materials are defined as materials containing particles within the size range of 1-100 nanometers (nm) in at least one direction and exhibiting one or more unique and novel properties different from properties at size ranges greater than 100 nm. Specific information to be collected includes chemical identity, production volume, methods of manufacture and processing, exposure and release, and available environmental, health and safety information. The information gathered under TSCA section 8(a) may facilitate EPA in identifying potential sources of ENM-containing wastewater.

#### **6.1.4 ENM Standard Methods and Sampling Techniques**

EPA's more recent research indicates that methods for detecting, quantifying, and characterizing nanomaterials in complex environmental media, such as industrial wastewater, are still not fully developed (CPSC, 2016; Part, et al., 2015). However, EPA has identified some

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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advances in methods that rely on advanced microscopy or spectroscopy (e.g., hyperspectral imagery, scanning electron microscopy, confocal microscopy, energy-dispersive spectroscopy, near-infrared fluorescence), which have demonstrated success in detecting ENMs in some complex media (e.g., biological samples, wetland water, wastewater) (Badireddy, et al., 2012; CPSC, 2016; Part, et al., 2015; Selck, et al., 2016).

In general, academic and government researchers continue to use very sophisticated instrumentation to measure some of the most common ENM characteristics (e.g., particle size, shape, structure, surface area, concentration, agglomeration), but the appropriate analytical technique depends on the composition of ENM and the surrounding media. EPA's research suggests that standardizing methods to measure ENMs in complex media continues to be challenging due to the complexity caused by matrix issues, and the expense and limited availability of the instrumentation (Salamon, 2013; Selck, et al., 2016; von der Kammer, et al., 2012). To date, EPA has not approved standardized methods for sampling, detecting, monitoring, quantifying, or characterizing nanomaterials in aqueous media.

#### ***6.1.5 Fate, Transformation, and Treatment of ENMs in Industrial Wastewaters***

EPA identified several modeling efforts which show that the fate of ENMs through their life cycle vary depending on application. For example, Researchers at the University of California Center for Environmental Implications of Nanotechnology estimated that 60 to 86 percent of ENMs used globally (with the majority from applications in electronics, motor vehicles, and solar panels) end up in landfills (Keller & Lazareva, 2014). Researchers at Empa, Switzerland, used probabilistic material-flow modeling to determine the life cycle of ENMs in the European Union. They showed that ENMs used in coatings, pigments, and cosmetics (i.e., TiO<sub>2</sub> and ZnO), primarily flow from production, manufacturing, and consumption (PMC) to wastewater treatment plants, and that carbon-based ENMs go largely from PMC to recycling facilities, or are burned (Sun, et al., 2014).

EPA did not identify research on the fate of ENMs specifically released by the production and manufacturing phases, though these life cycle assessments suggest that end of life (consumption of end use products) release may be a significant source of ENMs to POTWs. Regardless of the source, research continues to suggest that the majority of nanoparticles likely partition to sewage sludge (Eduok, et al., 2015; Kaegi, et al., 2013; Westerhoff, et al., 2011). Nanoparticles sorb to biomass and are subsequently removed from wastewater through settling or filtration during wastewater treatment; however, removal efficiency strongly depends on the size of the nanomaterials (Westerhoff, et al., 2011).

EPA's research suggests that characterizing ENMs and understanding their fate in industrial wastewater continues to be challenging due to interactions with other environmental substances and processes, which may alter ENM properties and behavior. Chemical reactions with an aqueous environment, such as adsorption of organic ligands, metals, and naturally occurring colloids, can cause modifications to the ENM surface and may alter the fate and bioavailability of the ENM, as compared to pristine ENMs, (Eduok, et al., 2015; Selck, et al., 2016), thus potentially affecting its behavior during biological wastewater treatment.

Research suggests that nanomaterials may impact the functionality of necessary biota in biological treatment processes, although the effects on biological removal of pollutants are not

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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yet conclusive (Eduok, et al., 2015; Westerhoff, et al., 2013). Within laboratory testing, silver nanoparticles have been found to significantly inhibit nitrification rates by nitrifying bacteria, such as *Nitrosomonas* and *Nitrobacter* (Hristozov, et al., 2016) and reduce nitrifying capacity in a bioreactor (Westerhoff, et al., 2013). Researchers found that titanium dioxide nanoparticles showed no short-term effects on nutrient removal, but after long term exposure (70 days), decreased total nitrogen removal efficiency (Zheng, et al., 2011). Researchers at Cranfield University, UK, investigated the effects of a mixture of silver oxide, titanium dioxide, and zinc oxide ENMs on pilot biological wastewater treatment systems. They found that the ENM mixture inhibited ammonia and nitrite-oxidizing bacteria, while other microorganisms seemingly tolerant to the ENMs thrived. Although there was a shift in the microbial community structure and diversity, researchers did not observe any significant changes in removal of organic matter or ammonia (Eduok, et al., 2015).

On the other end of the spectrum, ENMs have shown promise when used in water and wastewater treatment systems, either as treatment chemicals or integrated into filter and membrane materials, to remove other pollutants of concern. The most studied ENMs for wastewater treatment are zero-valent metal nanoparticles (e.g., Ag, Fe, and Zn), metal oxide nanoparticles (e.g., TiO<sub>2</sub>, ZnO, and iron oxides), and carbon nanomaterials (Lu, et al., 2016).

Zero-valent metal nanoparticles, such as zero-valent iron (ZVI) are being evaluated to remove various organic and inorganic pollutants in water, such as arsenic, hexavalent chromium, copper, and lead (Bora & Dutta, 2014). Researchers also found ZVI to be effective at decomposing nitrobenzene, a feedstock material used to produce pharmaceuticals, dyes, and pesticides (Lee, et al., 2015). Metal oxides are being evaluated for their potential to photocatalytically degrade organic compounds (e.g., humic acid, color, silver nitrate) and microorganisms harmful to human health, such as *E. coli* and *S. mutans* (Bora & Dutta, 2014).

Carbon nanomaterials are widely studied for use in membrane fabrication. Carbon nanotubes (CNTs) have high solvent permeability while blocking chemical and biological pollutants. Activated carbon is already extensively used as a sorbent to remove organic and inorganic chemicals from wastewater, and CNTs are being evaluated as adsorbent materials (Bora & Dutta, 2014). Though this body of research indicates promising uses of ENMs in wastewater treatment, it also signals another potential source of ENMs in wastewater discharges if the applications are not adequately controlled.

#### **6.1.6 Summary of ENM Review**

Based on the information gathered during EPA's current review, research continues to suggest that ENMs are used in a wide range of industrial applications and domestic products, but little is known about production quantities, waste management practices, or the potential for release of ENMs from most industrial waste streams. However, EPA has identified that nanomaterials, specifically ceria, used in CMP in the electronics industry may be released into wastewater and have the potential to be discharged to the environment. Further, the quantity of nanomaterials released varies with the process operations employed.

Methods for detecting and characterizing nanomaterials in complex media, including industrial wastewater, are under development. However, only incremental progress has been made to date towards developing standard measurement methods, which are needed before EPA

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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can demonstrate the extent of ENMs in industrial discharges, and the efficacy of various wastewater treatment technologies to remove ENMs from industrial wastewater.

Some research suggests that ENMs may impact the effectiveness of biological wastewater treatment systems, with specific studies suggesting impacts to nitrification and nutrients removal. In contrast to those concerns, recent information suggests a trend toward using ENMs in water and wastewater treatment to remove or degrade specific pollutants, such as metals, organic compounds, and microorganisms. These treatment applications may also be a potential source of environmental release if not adequately managed.

Consistent with results from its 2014 Annual Review (U.S. EPA, 2015a), EPA will continue to identify data gaps related to (1) potential sources, quantities, and types of ENMs in industrial wastewater discharge; (2) fate, transformation, and treatment of ENMs in industrial wastewaters, including their potential impact to wastewater treatment system biota and beneficial use to enhance wastewater treatment, and (3) the development of standard methods to detect and quantify ENMs. Filling these data gaps will enable EPA to assess more fully the potential presence and impact of ENMs in industrial process water.

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6—EPA's Continued Investigations of Pollutants and Treatment Technologies  
Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater

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6—EPA's Continued Investigations of Pollutants and Treatment Technologies  
Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater

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*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.1—Continued Review of Engineered Nanomaterials (ENMs) in Industrial Wastewater*

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## 6.2 Continued Review of Industrial Wastewater Treatment Technologies

The Clean Water Act (CWA) directs EPA to establish Effluent Limitations Guidelines and Standards (ELGs) based on the performance of the best treatment technologies available, application of best management practices, or implementation of process changes. As described in EPA's 2002 Draft National Strategy (67 FR 71165), EPA considers several factors when developing its Effluent Guidelines Program Plans, including the availability of wastewater treatment technologies. EPA may choose to revise existing ELGs for a point source category if it identifies an applicable and demonstrated technology, process change, or pollution prevention approach that would reduce the concentrations of pollutants in the discharged wastewater.

In its *Final 2012 and Preliminary 2014 Effluent Guidelines Program Plans* (79 FR 55472), EPA announced that it had initiated a review of relevant literature to document the performance of new and improved industrial wastewater treatment technologies. EPA captures these performance data in a searchable Industrial Wastewater Treatment Technology (IWTT) Database. IWTT is a critical component of EPA's annual reviews, including this review. EPA uses IWTT, in part, to answer the following questions:

- What new technologies or changes to existing technologies are industries using to treat their waste streams?
- Are there technologies that can reduce or eliminate wastewater pollutants not currently regulated by ELGs, or remove pollutants to a degree that exceeds current regulatory standards?

EPA's *2012 Annual Effluent Guidelines Review Report* (2012 Annual Review Report) (U.S. EPA, 2014) and *Supplemental Quality Assurance and Control Plan for Development and Population of the Industrial Wastewater Treatment Technology Database* (ERG, 2013) describe the IWTT data collection methods, data sources, data quality assurance and control criteria, and the proposed plan for data storage. The *2014 Annual Effluent Guidelines Review Report* (2014 Annual Review Report) (U.S. EPA, 2015) describes the database structure and the data elements captured. The 2014 Annual Review Report also provides a detailed summary of the information captured in the database at that time.

This section provides an updated overview of the data collected in IWTT to date. Sections 4.1, 4.2, 4.3, and 5.2 of this report present EPA's analysis of IWTT data related to specific industry category reviews, conducted as part of the current review.

### 6.2.1 *Updated IWTT Literature Review Summary*

EPA's initial efforts to build and populate IWTT are described in the 2014 Annual Review Report (U.S. EPA, 2015). Building upon prior data collection efforts, EPA continued to collect wastewater treatment performance data by identifying and screening 130 references from two key technical conferences on wastewater treatment. These conferences included presentations across a broad range of industries: 2015 Water Environment Federation's Technical Exhibit and Conference and 2015 International Water Conference.

EPA screened all identified literature and data sources against the established data quality criteria described in Section 6.6.1.3 of the 2012 Annual Review Report (U.S. EPA, 2014) and the

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.2—Continued Review of Industrial Wastewater Treatment Technologies*

*Supplemental Quality Assurance and Control Plan for Development and Population of the Industrial Wastewater Treatment Technology Database (ERG, 2013).*

To date, EPA has identified and screened a total of 561 articles. Of those, 191 met the quality criteria and database entries were created for each article in IWTT. Appendix C comprises a complete bibliography of the articles that have been entered into the database to date.

### **6.2.2 Updated Summary of Data Captured in IWTT**

EPA focuses on capturing wastewater treatment performance data (e.g., pollutant removals, influent and effluent concentrations) about pilot- and full-scale systems treating industrial wastewater. Table 6-1, Table 6-2, and Table 6-3 summarize the treatment technologies, industries, and pollutants documented in the database to date. The file *IWTT\_Export\_2016.xls* provides detailed output of the data in the IWTT Database (ERG, 2016).

The IWTT Database (*IWTT\_Export\_2016.xls*) currently contains data for 54 different treatment technologies (i.e., unit processes), some of which may be components of a larger treatment system (ERG, 2016). Table 6-1 lists the number of articles that describe each unit process, and the number of treatment systems that include each unit process. Twenty-eight treatment technologies, or 52 percent of the technologies in the database, are described in five or more articles. The treatment technology classifications were developed to capture and compare unit processes within a treatment system. In order to standardize information for evaluation across articles, treatment unit classifications vary in specificity. Appendix H of the 2014 Annual Review Report provides descriptions and categorization information about the treatment technologies (U.S. EPA, 2015).

**Table 6-1. Pilot- and Full-Scale Treatment Unit Processes Documented in IWTT**

Unit Processes	Number of Articles Describing the Technology	Number of Treatment Systems Using the Technology <sup>a</sup>
Chemical precipitation	41	52
Flow equalization	35	41
Membrane bioreactor	33	45
Clarification	33	38
Membrane filtration	24	34
Dissolved air flotation	22	29
Aerobic suspended growth	22	23
Reverse osmosis	19	21
Granular-media filtration	19	21
Mechanical pre-treatment	16	22
Ion exchange	16	20
Aeration	13	14
Oil/water separation	12	14
Bag and cartridge filtration	10	14
Anaerobic biological treatment	10	12

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.2—Continued Review of Industrial Wastewater Treatment Technologies*

**Table 6-1. Pilot- and Full-Scale Treatment Unit Processes Documented in IWTT**

<b>Unit Processes</b>	<b>Number of Articles Describing the Technology</b>	<b>Number of Treatment Systems Using the Technology<sup>a</sup></b>
Aerobic biological treatment	9	11
Anaerobic fixed film biological treatment	8	12
Aerobic fixed film biological treatment	7	9
Granular activated carbon unit	7	8
Ultra violet	7	8
Adsorptive media	7	7
Moving bed bioreactor	7	7
Evaporation	6	11
Electrocoagulation	6	9
Anaerobic suspended growth	6	8
Liquid extraction	6	7
Biological nutrient removal	6	6
Biologically active filters	6	6
Constructed wetlands	5	8
Advanced oxidation processes, NEC	5	6
Stripping	4	5
Chemical oxidation	4	5
Degasification	4	4
Ozonation	3	4
Centrifugal separator	3	4
Ballasted clarification	3	3
Nanofiltration	3	3
Chemical disinfection	3	3
Powdered activated carbon	3	3
Crystallization	2	7
Biological treatment	2	2
Controlled hydrodynamic cavitation	2	2
Anaerobic membrane bioreactor	2	2
Denitrification filters	2	2
Integrated fixed-film activated sludge	2	2
Dechlorination	2	2
Hydrolysis, acid or alkaline	1	2
Biofilm airlift suspension reactor	1	1
Bioaugmentation	1	1
Cloth filtration	1	1
Zero valent iron	1	1
Dissolved gas flotation	1	1
Distillation	1	1
Granular sludge sequencing batch reactor	1	1

<sup>a</sup> Some articles may describe more than one wastewater treatment system.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.2—Continued Review of Industrial Wastewater Treatment Technologies*

As shown in Table 6-2, IWTT contains wastewater treatment technology performance data for 27 out of the 58 industrial point source categories currently regulated by effluent guidelines.<sup>56</sup> IWTT also includes treatment technology performance data for two industries not currently regulated, as well as several unclassifiable establishments. IWTT captures the removal performance of treatment systems for 195 different pollutants. Table 6-3 lists the pollutants having their associated treatment performances most frequently reported in IWTT. Table D-1 in Appendix D presents the complete list of pollutants with documented treatment performance.

**Table 6-2. Industries with Wastewater Treatment Performance Data in IWTT**

Point Source Category No.	Industry	Scale of Treatment System	Number of Treatment Systems
--	Agricultural services (SIC codes beginning with 07, excluding veterinary services)	Pilot	1
--	Non-classifiable establishments	Full	2
		Pilot	5
405	Dairy products processing	Full	1
407	Canned and preserved fruits and vegetables processing	Full	1
		Pilot	2
410	Textile mills	Full	1
		Pilot	2
412	CAFO	Full	2
419	Petroleum refining	Full	9
		Pilot	12
420	Iron and steel manufacturing	Full	2
		Pilot	2
421	Nonferrous metals manufacturing	Pilot	3
423	Steam electric power generating	Full	4
		Pilot	3
424	Ferroalloy manufacturing	Pilot	1
425	Leather tanning and finishing	Full	4
430	Pulp, paper and paperboard	Full	2
		Pilot	1
432	Meat and poultry products	Full	4
		Pilot	3
433	Metal finishing	Full	3
		Pilot	19
434	Coal mining	Full	2
		Pilot	7

<sup>56</sup> <https://www.epa.gov/eg/industrial-effluent-guidelines>

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.2—Continued Review of Industrial Wastewater Treatment Technologies*

**Table 6-2. Industries with Wastewater Treatment Performance Data in IWTT**

Point Source Category No.	Industry	Scale of Treatment System	Number of Treatment Systems
435	Oil and gas extraction	Full	2
		Pilot	8
437	Centralized waste treatment	Full	1
439	Pharmaceutical manufacturing	Full	3
		Pilot	1
440	Ore mining and dressing	Full	1
		Pilot	2
442	Transportation equipment cleaning	Full	1
445	Landfills	Full	1
455	Pesticide chemicals	Pilot	1
460	Hospital	Full	1
		Pilot	1
467	Aluminum forming	Full	1
469	Electrical and electronic components	Full	1
		Pilot	5
--	Miscellaneous foods and beverages	Full	3
		Pilot	6

-- Not a regulated point source category.

**Table 6-3. Pollutants with Performance Data Most Frequently Reported in IWTT**

Pollutant <sup>a</sup>	Number of Treatment Systems
Chemical oxygen demand (COD)	60
Total suspended solids (TSS)	49
Biochemical oxygen demand (BOD)	27
Total dissolved solids (TDS)	26
Phosphorus, total	23
Nitrogen, Kjeldahl total (TKN)	19
Total organic carbon (TOC)	18
Ammonia (as N)	17
Chemical oxygen demand (COD), total	16
Nitrogen, total	14
Selenium, total	13
Nickel	13
Conductivity	12
Chloride	12
BOD5	12
Oil and grease	12

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.2—Continued Review of Industrial Wastewater Treatment Technologies*

**Table 6-3. Pollutants with Performance Data Most Frequently Reported in IWTT**

Pollutant <sup>a</sup>	Number of Treatment Systems
Copper	11
Nitrate (as N)	11
Cadmium	11
Chromium	10
Ammonia (as NH <sub>3</sub> )	10
Zinc	10
Ammonium-nitrogen	10

<sup>a</sup> Pollutant names are only as specific as the names stated in each article.

### **6.2.3 References for the Continued Review of Industrial Wastewater Treatment Technologies**

1. ERG. 2013. Eastern Research Group, Inc. Supplemental Quality Assurance and Control Plan for the Development and Population of the Industrial Wastewater Treatment Technology Database. Chantilly, VA. (November 22). EPA-HQ-OW-2010-0824-0263.
2. ERG. 2016. Eastern Research Group, Inc. *Export of Industrial Wastewater Treatment Technology (IWTT) Database Tables*. Chantilly, VA. (September). EPA-HQ-OW-2015-0665. DCN 08383.
3. U.S. EPA. 2014. *The 2012 Annual Effluent Guidelines Review Report*. Washington, D.C. (September). EPA-HQ-OW-2010-0824-0320.
4. U.S. EPA. 2015. *The 2014 Annual Effluent Guidelines Review Report*. Washington, D.C. (July). EPA-HQ-OW-2014-0170-0209.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

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### **6.3     Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals Manufacturing Effluent Limitations (40 CFR Part 455)**

As part of the 2012 Annual Review, EPA reviewed analytical methods it had recently developed or revised to facilitate identification of pollutants in industrial wastewater discharges (U.S. EPA, 2014a), including a review of EPA Office of Water's 2012 updates to the test procedures for the analysis of pollutants under the Clean Water Act (CWA) (2012 Method Update Rule) (77 FR 29758). Based on changes made in the 2012 Methods Update Rule, EPA identified 30 pesticide active ingredients (PAIs) which do not currently have PAI-specific effluent limitations for pesticide chemicals manufacturing under the Pesticide Chemicals effluent limitation guidelines and standards (ELGs) (40 CFR Part 455), although some may have been considered during the development of the ELGs (U.S. EPA, 2014a). As part of the 2014 Annual Review, EPA evaluated the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 3 registration status of these 30 PAIs and identified data sources that may shed further light on the status of manufacturing of these PAIs in the U.S. (U.S. EPA, 2015).

EPA followed up on the analyses conducted in the 2012 and 2014 Annual Reviews in the current review. Specifically, EPA further evaluated the 30 PAIs of interest to (1) learn if any are manufactured in the U.S., (2) identify wastewater discharges, and (3) review available environmental fate and human health information. EPA used data about the 30 PAIs of interest collected under the FIFRA, as well as discharge monitoring report (DMR), Toxics Release Inventory (TRI), and toxicology data.

Section 6.3.1 provides a background of the Pesticide Chemicals Category (40 CFR Part 455). Sections 6.3.2 through 6.3.5 present EPA's current review approach and evaluation of the 30 PAIs without PAI-specific effluent limitations for pesticide chemicals manufacturing under the Pesticide Chemicals ELGs, including its review of FIFRA, DMR, TRI, and toxicology data sources. Section 6.3.6 summarizes the results from EPA's current review.

#### **6.3.1     *Pesticide Chemicals Category Background***

EPA last promulgated ELGs for the Pesticide Chemicals Category (40 CFR Part 455) in 1993 for facilities that manufacture organic and metallo-organic PAIs. These discharges are regulated under Subparts A and B, respectively. EPA also revised the ELGs in 1996 for facilities that formulate, package, and repackage pesticide products. These discharges are regulated under Subparts C and E. As such, the Pesticide Chemicals ELGs regulate wastewater discharges from four subcategories:

- Subpart A: Organic Pesticide Chemicals Manufacturing
- Subpart B: Metallo-Organic Pesticide Chemicals Manufacturing
- Subpart C: Pesticide Chemicals Formulating and Packaging
- Subpart E: Repackaging of Agricultural Pesticides Performed at Refilling Establishments

The ELGs define the following terms related to pesticides:

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

---

- *Pesticide.* Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest.
- *Active ingredient.* An ingredient of a pesticide that is intended to prevent, destroy, repel, or mitigate any pest.
- *Pesticide chemicals.* The sum of all active ingredients manufactured at each facility covered by 40 CFR Part 455.
- *Formulation of pesticide products.* The mixing, blending, or diluting of one or more PAIs with one or more active or inert ingredients, without an intended chemical reaction, to obtain a manufacturing use product or an end-use product.

Subparts A and B set ELGs applicable to pesticide chemicals manufacturing processes resulting from the manufacture of organic PAIs (with a few exceptions) and organo-tin PAIs (Subpart A), and all metallo-organic PAIs containing arsenic, mercury, cadmium, or copper (Subpart B). Subpart A limitations depend on the PAI manufactured. For facilities manufacturing any organic PAI, Subpart A sets limitations for biochemical oxygen demand (BOD), total suspended solids (TSS), pH, and chemical oxygen demand (COD). For facilities manufacturing specific PAIs (40 CFR Part 455 Table 1), Subpart A sets additional limitations for nonconventional pollutants (including limitations on the discharge of the PAI) and priority pollutants. Subpart A does not set effluent limitations for all PAIs manufactured in the United States.

Subpart B prohibits all discharges of process wastewater pollutants by facilities manufacturing metallo-organic PAIs containing arsenic, mercury, cadmium, or copper (U.S. EPA, 1993a, 1993b). Subparts C and E regulate pesticide formulating, packaging, and repackaging (PFPR) facilities. Subpart C prohibits discharges of process wastewater pollutants unless the facility incorporates certain pollution prevention alternative practices. Subpart E prohibits all discharges of process wastewater pollutants (U.S. EPA, 1996). When the last revisions of the Pesticide Chemicals ELGs were promulgated, very few facilities manufactured individual PAIs, and some PAIs were manufactured at just one facility (U.S. EPA, 1993b).

During the 1993 Pesticides Chemicals ELG revisions, EPA evaluated the manufacturing processes associated with 29 of the 30 PAIs of interest identified for EPA's current review (EPA did not evaluate Tokuthion (prothiofos), see Table 6-4). As discussed above, if a facility manufactures an organic PAI (with some exceptions), Subpart A sets limitations for BOD, TSS, pH, and COD. However, in 1993, EPA did not establish PAI-specific limitations for any of the 30 PAIs of interest. PAI-specific limitations may not have been set for the following reasons: the PAI was not manufactured since 1986; analytical methods were unavailable for the PAI; all wastewater discharges containing the PAI were disposed of in deep wells subject to regulation under EPA's Underground Injection Control (UIC) program; or there was insufficient data on their treatability (U.S. EPA, 1993a).

### **6.3.2 Introduction to EPA's 2016 Targeted Review of PAIs Without Pesticide Chemicals Manufacturing Effluent Limitations**

In its current review, EPA continued to investigate the 30 PAIs (listed in Table 6-4) that do not currently have PAI-specific effluent limitations for pesticide chemicals manufacturing under Subpart A in 40 CFR Part 455. Table 6-4 presents information on the regulation of the 30

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

PAIs under the Pesticide Chemicals ELGs (40 CFR Part 455) under Subpart A, as well as the FIFRA Section 3 registration status. See Section 6.3.3 for additional information on FIFRA.

**Table 6-4. Registration Status for 30 PAIs**

<b>EPA Method</b>	<b>PAI Name</b>	<b>CAS Number</b>	<b>Registration Status in Accordance with FIFRA Section 3</b>	<b>Subject to PAI-Specific ELGs Under 40 CFR Part 455, Subpart A</b>
608.1	Chlorobenzilate	510-15-6	All U.S. registrations have been canceled.	No
	Chloropropylate	5836-10-2	All U.S. registrations have been canceled.	No
	Dibromochloropropane	96-12-8	Never registered in the U.S.	No
	Etridiazole	2593-15-9	First registered in 1962; under registration review.	No
614.1	EPN	2104-64-5	All U.S. registrations have been canceled.	No
615	Dalapon	75-99-0	All U.S. registrations have been canceled.	No
617	Carbophenothion	786-19-6	All U.S. registrations have been canceled.	No
	Endosulfan sulfate	1031-07-8	Never registered in the U.S.	No
	Endrin aldehyde <sup>a</sup>	7421-93-4	Never registered in the U.S. All U.S. registrations of the parent compound, endrin, have been canceled.	No
	Heptachlor epoxide <sup>b</sup>	1024-57-3	Never registered in the U.S. All U.S. registrations of the parent compound, heptachlor, have been canceled.	No
	Isodrin	465-73-6	Never registered in the U.S.	No
	Strobane	8001-50-1	All U.S. registrations have been canceled.	No
619	Atraton	1610-17-9	Never registered in the U.S.	No
	Secbumeton	26259-45-0	Never registered in the U.S.	No
	Simetryn	1014-70-6	Never registered in the U.S.	No
622	Chlorpyrifos methyl	5598-13-0	First registered in 1985; under registration review.	No
	Coumaphos	56-72-4	First registered in 1958; under registration review.	No
	Ethoprop	13194-48-4	First registered in 1967; under registration review.	No
	Ronnel	299-84-3	All U.S. registrations have been canceled.	No
	Tokuthion	34643-46-4	Never registered in the U.S.	No
	Trichloronate	327-98-0	Never registered in the U.S.	No
622.1	Aspon	3244-90-4	All U.S. registrations have been canceled.	No
	Dichlofenthion	97-17-6	All U.S. registrations have been canceled.	No
	Famphur	52-85-7	All U.S. registrations have been canceled.	No
	Fenitrothion	122-14-5	First registered in 1975; under registration review. Only product registered in the U.S. is for formulating other insecticides. No end-use products registered in the U.S.	No
	Fonofos	944-22-9	All U.S. registrations have been canceled.	No

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

**Table 6-4. Registration Status for 30 PAIs**

<b>EPA Method</b>	<b>PAI Name</b>	<b>CAS Number</b>	<b>Registration Status in Accordance with FIFRA Section 3</b>	<b>Subject to PAI-Specific ELGs Under 40 CFR Part 455, Subpart A</b>
	Thionazin	297-97-2	All U.S. registrations have been canceled.	No
632	Fluometuron	2164-17-2	First registered in 1974; under registration review.	No
	Neburon	555-37-3	All U.S. registrations have been canceled.	No
	Oxamyl	23135-22-0	First registered in 1974; under registration review.	No

Source: (U.S. EPA, 2015)

Note: CAS Number – Chemical Abstracts Service Number

<sup>a</sup> Endrin aldehyde has never been a registered pesticide but is an impurity and breakdown product of a previously registered pesticide, Endrin. The Pesticide Chemicals ELGs (40 CFR Part 455) set a specific effluent limitation for Endrin.

<sup>b</sup> Heptachlor epoxide has never been a registered pesticide, but is a metabolite of a previously registered pesticide, Heptachlor. The Pesticide Chemicals ELGs (40 CFR Part 455) set a specific effluent limitation for Heptachlor.

EPA identified follow-up questions and data sources in the 2014 Annual Review that would provide additional information to show whether any of the 30 PAIs of interest are manufactured in the U.S. and are potentially present in industrial wastewater discharges. For the current review, EPA specifically focused on the following questions:

- Are any of the 30 PAIs of interest manufactured in the U.S.? If so, which facilities manufacture the PAIs?
- Are discharge data available for the PAIs of interest?
- Are toxicology data available for the PAIs of interest?

To answer these questions, EPA used multiple data sources, including EPA-managed databases (e.g., FIFRA Section 3 and Section 7 data) that contain confidential business information (CBI), and publicly available data (e.g., DMR, TRI, and toxicology data). Sections 6.3.3 through 6.3.5 discuss these data sources and the analyses performed.

### **6.3.3 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Data**

FIFRA regulates pesticide distribution, sale, and use in the U.S. The Code of Federal Regulations (CFR) defines the following pesticide terms related to the implementation of FIFRA:

- *Pesticide product.* A pesticide in the particular form (including composition, packaging, and labeling) in which the pesticide is, or is intended to be, distributed or sold. The term includes any physical apparatus used to deliver or apply the pesticide if distributed or sold with the pesticide. (40 CFR Part 152.3)
- *Technical grade of the active ingredient (TGAI).* A material containing an active ingredient that (1) contains no inert ingredient, other than one used for purification of

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

---

the active ingredient; and (2) is produced on a commercial or pilot plant production scale (whether or not it is ever held for sale). (40 CFR Part 158.300)

- *Manufacturing Use Product (MUP)*. Any pesticide product other than an end-use product. A product may consist of the technical grade of active ingredient only, or may contain inert ingredients, such as stabilizers or solvents. (40 CFR Part 158.300)
- *End-use product*. A pesticide product whose labeling (1) includes directions for use of the product (as distributed or sold, or after combination by the user with other substances) for controlling pests or defoliating, desiccating, or regulating the growth of plants, and (2) does not state that the product may be used to manufacture or formulate other pesticide products. (40 CFR Part 152.3 and 40 CFR Part 158.300)
- *Establishment*. Any site where a pesticide product, active ingredient, or device is produced, regardless of whether such site is independently owned or operated, and regardless of whether such site is domestic and producing a pesticide product for export only, or whether the site is foreign and producing any pesticide product for import into the United States. (40 CFR Part 167.3)
- *Produce*. To manufacture, prepare, propagate, compound, or process any pesticide, including any pesticide produced pursuant to Section 5 of the Act, any active ingredient or device, or to package, repackage, label, relabel, or otherwise change the container of any pesticide or device.<sup>57</sup> (40 CFR Part 167.3)

Section 3 of FIFRA outlines pesticide registration in the U.S. and provides EPA the authority to regulate the content and labeling of pesticide products. Pesticide products include TGAIs, MUPs, and end-use products, as defined above. TGAIs are chemically equivalent to PAIs (as defined in the ELGs); for clarity within this report and to remain consistent with the terminology established in the Pesticide Chemicals ELGs, EPA uses the term PAI in this report. PAIs are sold as MUPs. The MUPs may consist of the PAI only or the PAI and small amounts of inert ingredients. MUPs are mixed with inert ingredients to formulate end-use products (Robbins, 2016).

FIFRA Section 3 requires registration of pesticide products distributed or sold for use within the U.S. (Keigwin, 2014; U.S. EPA, 2014b). The MUP, and the PAI it contains, must be registered before the end-use product containing it can be registered (Robbins, 2016; U.S. EPA, 2016a). FIFRA Section 4 requires that pesticide product registrations, including the PAI registration, be reviewed every 15 years and requires EPA to reregister all pesticide products registered before 1984 in order to update labeling and use requirements. EPA may cancel a registration if the pesticide product does not comply with any one of the FIFRA requirements. After cancellation, any distribution, sale, or use of the pesticide product within the U.S. is prohibited (U.S. EPA, 2012a). EPA’s Office of Pesticides Programs (OPP) integrated system, Pesticide Registration Information System (PRISM) maintains information on U.S. pesticide registration and review as required under FIFRA Section 3. PRISM provides a centralized source of information on all registered pesticide products; the data contained in PRISM are considered

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<sup>57</sup> The use of the term “produce” throughout the remainder of this report section refers to this FIFRA-specific definition, see 40 CFR 167.3.

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

CBI (U.S. EPA, 2016b). Table 6-4 presents the FIFRA Section 3 registration status for the 30 PAIs.

Although Section 3 of FIFRA provides the authority to regulate the content and labeling of pesticide products through registration, it does not provide the authority to regulate pesticide manufacturing. Pesticide products manufactured for distribution in the U.S. are exempt from Section 3 under certain circumstances, and pesticide products manufactured solely for export do not require U.S. registration. Therefore, the registration status of a particular pesticide product (e.g., canceled, never registered) may not indicate which pesticide products are manufactured in the U.S., especially if they are only manufactured for export (Keigwin, 2014).

Section 7 of FIFRA requires all domestic and foreign establishments<sup>58</sup> producing pesticide products to register with the appropriate EPA Regional office and to report the types and amounts of pesticide products they produce (U.S. EPA, 2012a). FIFRA Section 7 reporting includes facilities manufacturing pesticide products solely for export (Keigwin, 2014; U.S. EPA, 2012a). The FIFRA Section 7 data are compiled in the Section Seven Tracking System (SSTS) database. The SSTS database is considered a part of the PRISM system. The names of establishments producing PAIs and their annual production volumes in the SSTS database are considered CBI (U.S. EPA, 2016c).

Section 6.3.3.1 presents the methodology EPA used to review the FIFRA data, including details on the PRISM and SSTS databases, contents, and limitations. Section 6.3.3.2 presents the results from EPA’s review of FIFRA Section 3 and Section 7 data.

### **6.3.3.1 FIFRA Data Methodology**

EPA reviewed information on the 30 PAIs of interest in the PRISM and SSTS databases. PRISM contains information on all pesticide products registered under FIFRA Section 3, including MUPs (both those consisting entirely of PAIs and those with a small percentage of other inert ingredients) and end-use products. SSTS contains information on individual facilities registered under FIFRA Section 7 and the products they produce, including MUPs and end-use products.

#### ***Pesticide Registration Information System (PRISM) Database***

The PRISM database contains FIFRA Section 3 information on all registered pesticide products in the U.S. EPA’s Office of Water (OW) contacted EPA’s OPP to discuss the quality and limitations of the information provided in PRISM and to access it for this review. The data collected in PRISM are particularly useful for the current review because PRISM:

- Includes the registration status for pesticide products that are produced (as defined in 40 CFR Part 167.3) in the U.S. for distribution, sale, or use within the U.S., including those with cancelled registrations.
- Identifies pesticide products by product name.

<sup>58</sup> As noted above, an establishment includes any site where a pesticide product, active ingredient, or device is produced, including sites that are independently owned or operated, domestic sites that produce a pesticide product for export only, and foreign sites that produce any pesticide product for import into the United States.

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

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- Identifies pesticide products by chemical ingredients, including PAIs that make up MUPs or are components of end-use products.

The information provided in PRISM is particularly useful because it provides a method to identify the PAI chemical and brand names to use in searching the SSTS database. Despite its utility, EPA recognizes that there are limitations to the data provided in the PRISM database. The database only includes information on pesticide products registered under FIFRA Sections 3 and 4 for distribution, sale, or use within the U.S., and therefore, does not indicate whether the pesticide product is currently manufactured in the U.S. It does not include information for pesticide products exempt from Section 3 registration, or for products that may be manufactured in the U.S. for export only. Despite these limitations, EPA determined that the information provided in PRISM was sufficiently accurate, reliable, and representative for this review, specifically to identify the current registration status of the 30 PAIs of interest and identify alternative pesticide product names (including MUPs) under which the PAIs may be included or sold.<sup>59</sup>

### ***Section Seven Tracking System (SSTS) Database***

The SSTS database contains information on establishments producing (as defined by 40 CFR 167.3) pesticide products, including MUPs. The SSTS database contains the following information:

- General establishment and company information (e.g., name, contact information).
- Product registration status and information.
- Product name (e.g., common brand names, alternate brand names).
- Product classification (e.g., insect repellant, herbicide, rodenticide).
- Product type (e.g., MUP (also called “Technical” products in SSTS) or PAI, end-use product, repackaged, or relabeled).
- Market status in the U.S. (e.g., marketed in the U.S., marketed in the U.S. and exported, solely exported).
- “Restricted Use” pesticide status.
- Amount produced.
- Amount sold or distributed in the U.S.
- Amount sold or distributed to foreign markets.
- Amount estimated to be produced in the following year.

Any information in SSTS that links an establishment or company to a product, and the amount of production, is considered CBI. EPA’s OW contacted EPA’s OPP to discuss the quality and limitations of the information provided in SSTS and to access it for this review (Ruple, 2016). Establishments are required to submit Section 7 registration requests and annual data to their EPA regional pesticide establishment coordinator. However, the SSTS database is not a required reporting method for establishments. Therefore, the database may not contain the

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<sup>59</sup> See Appendix A of this report for more information on data usability and the quality of data sources supporting these reviews.

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

---

same up-to-date or comprehensive information on production quantities that has been submitted to EPA regions.

The SSTS database is searchable only by pesticide product brand or trade name; it is not possible to search it by PAI or Chemical Abstracts Service Registry Number (CAS Number). Accordingly, EPA’s search for information on the manufacture of PAIs and MUPs consisting of PAIs was limited to products whose brand or trade names that could be identified. Additionally, the SSTS database does not distinguish whether an establishment is manufacturing and/or formulating pesticide products, and it may not contain the same up-to-date or comprehensive information on production quantities that the establishment submitted to EPA regions, as discussed above. Despite these limitations, EPA determined that the information in SSTS was sufficiently accurate, reliable, and representative for this review, specifically to identify establishments producing MUPs that contain the PAIs of interest, which would indicate the potential for their manufacture in the U.S.<sup>60</sup>

#### ***Other Data Sources***

As discussed above, there are some gaps in the PRISM and SSTS data. Therefore, EPA reviewed additional databases, including two publicly available chemistry databases: the National Institutes of Health (NIH) PubChem database and the Pesticide Action Network (PAN) Pesticides database. EPA used these databases to compile additional brand and trade names for each PAI (Kegley, et al., 2016; NCBI, 2016).

EPA also searched two additional OPP databases: the Foreign Purchaser Acknowledgement Statement (FPAS) database, to identify any exports of the PAIs of interest, and the Office of Pesticides Programs Information Network (OPPIN) database, EPA OPP’s predecessor database to PRISM, to identify the registered intended use of each PAI in the U.S. (OPPIN, 2016). The data contained in these databases are considered CBI.

#### ***Methodology for Searching PRISM and SSTS***

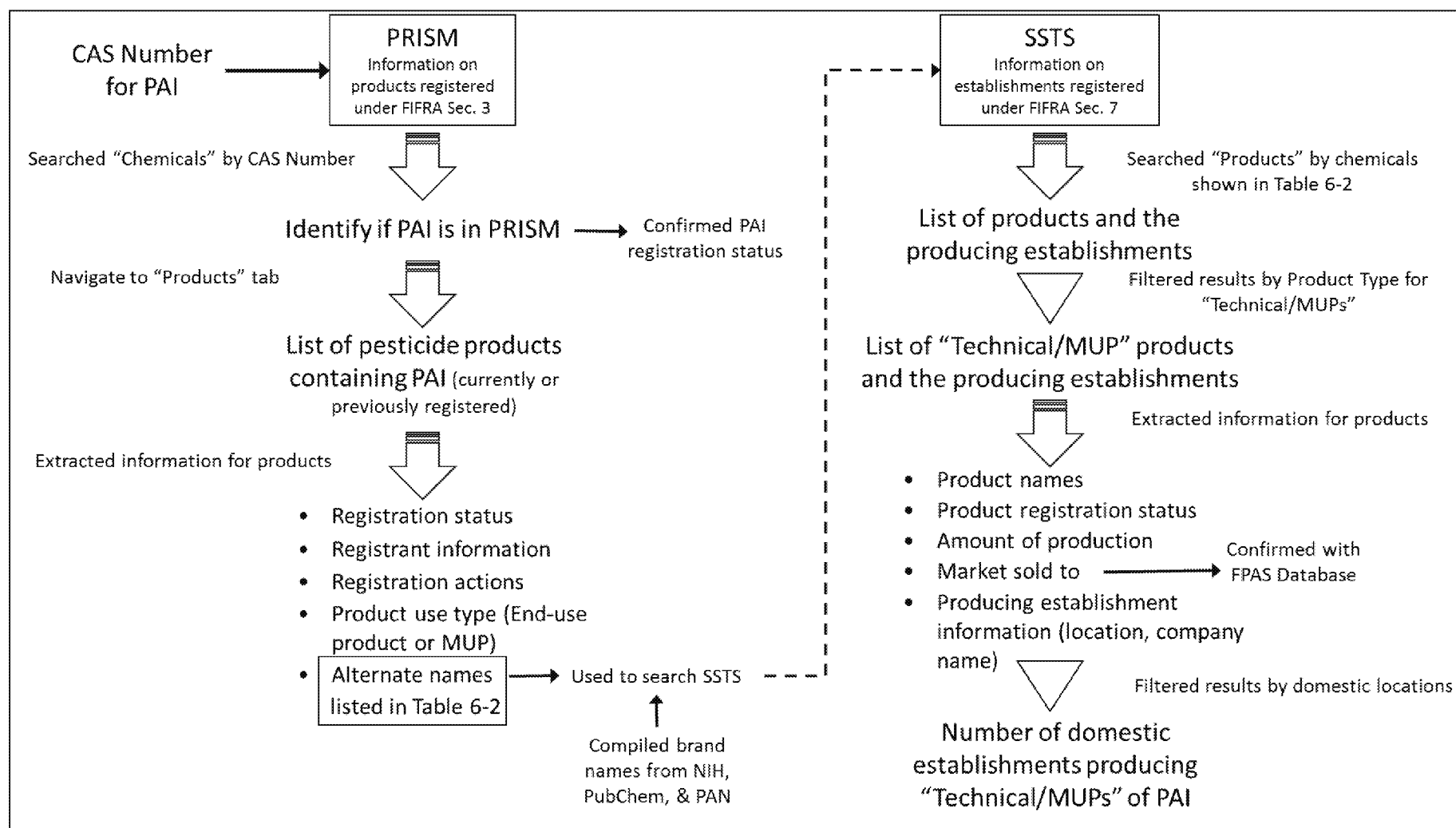
Figure 6-1 summarizes the basic methodology that EPA followed for extracting information from the PRISM and SSTS databases.

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<sup>60</sup> See Appendix A of this report for more information on data usability and the quality of data sources supporting these reviews.

## 6—EPA's Continued Investigations of Pollutants and Treatment Technologies

## Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals Manufacturing Effluent Limitations (40 CFR Part 455)



**Figure 6-1. Methodology Used in the Current Review to Access FIFRA Data through the PRISM and SSTS Databases and Identify Facilities Potentially Manufacturing PAIs**

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

Every chemical substance described in scientific literature is assigned a unique numeric identifier, a CAS number, by the Chemical Abstracts Service (Chemical Abstracts Service, 2016). Each of the 30 PAIs of interest has a unique CAS Number (listed in Table 6-5), despite potentially being sold under a variety of MUP brand or trade names. The PRISM database interface allows the user to search for chemicals by CAS Number. If the resulting identified PAI has ever been registered under FIFRA Section 3, additional information is available, including alternative chemical names, a list of all currently or previously registered pesticide products containing the PAI (MUPs and/or end-use products), and the PAI's current registration status. EPA performed this search for each of the 30 PAIs of interest and used the results to identify chemical names and to confirm each PAI's registration status (listed in Table 6-1). EPA also compiled the brand and trade names associated with the pesticide products containing the PAIs to facilitate comprehensive searches in the SSTS database for establishments potentially producing the PAIs (listed in Table 6-5).

To supplement the information found in PRISM, EPA searched the NIH PubChem database, and the PAN Pesticides database by PAI CAS Number to compile additional potential brand and trade names for each PAI (Kegley, et al., 2016; NCBI, 2016). The NIH and PAN databases were used in conjunction with PRISM to ensure that the search for information in SSTS was comprehensive, particularly in cases where an MUP may be manufactured in the U.S. only for export, and therefore, would not be identified in PRISM. EPA included the alternative names in Table 6-5.

**Table 6-5. Alternative Names for Pesticide Products Containing PAIs**

PAI Name	CAS Number	Chemical Name in PRISM	Brand or Trade Names
Aspon	3244-90-4	O,O,O,O-Tetrapropyl dithiopyrophosphate	NPD
Atraton	1610-17-9	1,3,5-Triazine-2,4-diamine, N-ethyl-6-methoxy-N'-(1-methylethyl)-	Atratone, Atrazine-methoxy, Atrotan, Gesatamin
Carbophenothion	786-19-6	None identified	Acarithion, Akarithion, Cabofenotion, Carbophenothion, Carbofenthion, Dagadip, Endyl, Garrathion, Hexathion, Karbophenothion, Lethox, Nephocarp, Oleokarithion, Rithion, Trithion
Chlorobenzilate	510-15-6	Ethyl 4,4'-dichlorobenzilate	Acar, Akar, Ben-O-chlor, Benzilan, Benzilen, Benz-O-chlor, Chlorbenzilat, Chlorobenzylate, Folbex, Kop-mite, Kopmite
Chloropropylate	5836-10-2	Isopropyl 4,4'-dichlorobenzilate	Acaralate, Chlormite, Chloropropylat, Chlorpropylat, Chlorpropylate, Gesakur, Rospan, Rospine, Rospine
Chlorpyrifos methyl	5598-13-0	None identified	Chlormethylfos, Chloropyriphos methyl, Chlorpyriphos methyl, Dursban methyl, Noltran, Reldan, Storcide, Trichlormethylfos, Tumar, Zertell
Coumaphos	56-72-4	None identified	Agridip, Asunthol, Asuntol, Azunthol, Balcom, Baymix, Checkmite, Co-ral, Corathon, Coumafos, Coumafosum, Coumarin, Cumafos, Cumafosum, Diolice, Meldane, Meldone, Muscatox, Negashunt,

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

**Table 6-5. Alternative Names for Pesticide Products Containing PAIs**

PAI Name	CAS Number	Chemical Name in PRISM	Brand or Trade Names
			Negasunt, Resitox, Suntol, Umbelliferone, Umbethion
Dalapon	75-99-0	None identified	Alatex, Basfapon, Basinex, Crisapon, Dalaphon, Dalascam, Davpon, Dawpon, Fydulan, Granulat, Kenapon, Liropon, Omnidel, Proprop, Radapon, Tafapon, Tripon, Unipon, Uropon
Dibromochloropropane	96-12-8	1,2-Dibromo-3-chloropropane	DBCP, Fumagon, Fumazone, Nemabrom, Nemaflume, Nemagon, Nemagone, Nemanax, Nemanex, Nemapaz, Nemaset, Nemaset, Nemazon
Dichlofenthion	97-17-6	None identified	Bromex, Dichlophenthion, ECP, Hexanema, Mobilawn, Nemacide
Endosulfan sulfate	1031-07-8	6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzodioxathiepin-3,3-dioxide	Thiodan sulfate
Endrin aldehyde	7421-93-4	None identified	None identified
EPN	2104-64-5	O-Ethyl O-(p-nitrophenyl) phenylphosphonothioate	Kasutop, Meidon, Santox, Tsumaphos
Ethoprop	13194-48-4	None identified	Ethioprophos, Ethoprophos, Etoprofos, Jolt, Menap, Mobil, Mocap, Phophos, Phosethoprop, Prophos, Rovokil
Etridiazole	2593-15-9	None identified	Aaterra, Banrot, Echlomezole, Echlomezole, Etcmtb, Ethazol, ETMT, Etridiazol, Koban, Pansoil, PCNB, Pentachloronitrobenzene, Planvate, Temik, Terraclor, Terracoat, Terraflo, Terramaster, Terrazole, Truban
Famphur	52-85-7	Phosphorothioic acid, O-(4-((dimethylamino)sulfonyl)phenyl) O,O-dimethyl ester	Bash, Bo-Ana, Dovip, Famfur, Famofos, Famophos, Fanfos, Warbex, Warbexol
Fenitrothion	122-14-5	None identified	Accothion, Aceothion, Agria, Agriya, Agrothion, Akotion, Arbogal, Cekutrothion, Cyfen, Cytel, Dicofen, Falithion, Fenition, Fenitox, Folithion, Insectigas, Kotion, Macbar, Metathion, Metathione, Metathionine, Metation, Methylnitrophos, Mglawik, Nitrophos, Novathion, Nuvanol, Oleometathion, Oleosumifene, Ovadofos, Owadofos, Owadophos, Sumigran, Sumithion, Sumitomo, Verthion
Fluometuron	2164-17-2	None identified	Cortoran, Cotogard, Cotoran, Cottonex, Flomet, Flo-Met, Fluomethuron, Higalcoton, Kotoran, Lanex, Meturon, Pakhtaran, Shotaran

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

**Table 6-5. Alternative Names for Pesticide Products Containing PAIs**

PAI Name	CAS Number	Chemical Name in PRISM	Brand or Trade Names
Fonofos	944-22-9	None identified	Difonate, Difonatul, Dyfonat, Dyfonate, Dyphonate
Heptachlor epoxide	1024-57-3	None identified	Epoxyheptachlor, Velsicol
Isodrin	465-73-6	None identified	None identified
Neburon	555-37-3	None identified	Granurex, Herbalt, Kloben, Naburon, Neburea, Neburex
Oxamyl	23135-22-0	None identified	Dioxamyl, Oxamil, Thioxamyl, Vydate
Ronnel	299-84-3	None identified	Blitex, Deramafosu, Dermafos, Dermaphos, Ectoral, Etrolene, Fenchloorfos, Fenchlorfos, Fenchlorfosu, Fenchlorphos, Fenchlorphos, Fenchofos, Fenclofosum, Fenclos, Gesektin, Korlan, Korlane, Nanchor, Nanker, Nankor, Phenchlorfos, Pyroicide, Remelt, Rid-Ezy, Rovin, Smear, Trichlorometafos, Trolene, Viozene
Secbumeton	26259-45-0	1,3,5-Triazine-2,4-diamine, N,N'-diethyl-6-(methylthio)-	Etazin, Etazine, Ezitan, Isobumeton, Secbumetone, Secumbeton, Sumitol, Terbut
Simetryn	1014-70-6	None identified	Cymetrin, Simetryne
Strobane	8001-50-1	None identified	Citicide, Polychloroterpenes, Terpene polychlorinates
Thionazin	297-97-2	O,O-Diethyl O-2-pyrazinyl phosphorothioate	Cynem, Cynophos, Nemafof, Nemafof, Nemafof, Thinozim, Thionazine, Zinofos, Zinophos, Zynophos
Tokuthion	34643-46-4	O-(2,4-Dichlorophenyl) O-ethyl S-propyl phosphorodithioate	Bideron, Dichlorpropaphos, Prothiofos, Prothiophos, Toyodan, Toyothion
Trichloronate	327-98-0	O-Ethyl O-(2,4,5-trichlorophenyl) ethylphosphonothioate	Agrisil, Agritox, Fenophosphon, Fitosol, Phytosol, Richloronate, Trichloronat

Source: (Kegley, et al., 2016; NCBI, 2016; U.S. EPA, 2016a)

EPA then used the compiled names listed in Table 6-5 to search the SSTS database (as the SSTS database is not searchable by CAS Number). The SSTS database does not indicate whether an establishment is manufacturing or formulating pesticide products, so EPA cannot conclude whether the establishments identified in its search are manufacturing or formulating the PAIs of interest. For instance, establishments could manufacture MUPs consisting of the PAI only, and therefore, may manufacture the PAI on premise. Alternatively, the establishment could formulate MUPs that consist of the PAI and a small proportion of inert ingredients, such as stabilizers. These establishments may either manufacture the PAI on premise, and immediately incorporate it into a MUP, or could purchase the PAI from another manufacturer, including a foreign manufacturer, and then formulate the MUP. Similarly, establishments producing end-use products could also manufacture a PAI on premise for immediate incorporation into the product, without ever distributing or selling the PAI in a MUP. However, establishments producing end-use products usually purchase PAIs from other domestic or foreign manufacturers (Niess, 2016).

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

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Given the above scenarios, EPA focused its review of the SSTS database on establishments producing MUPs to narrow the focus, to the extent possible, to the PAIs that are most likely manufactured in the U.S.<sup>61</sup> The SSTS database interface allows the user to search for establishments by the Product Name. The resulting list of products and their corresponding establishments can then be filtered by Product Type for “End- Use Product” or “Technical/MUP.”

EPA searched for each of the 30 PAIs using the names listed in Table 6-5, filtering on the Product Type “Technical/MUP.” The resulting list of MUPs contains detailed information including product name, product registration status, producing establishment name, location and contact information, the amount of annual production from that establishment, and the market to which the product is sold (e.g., domestic, foreign, or both). EPA used this information to identify the establishment names and locations producing MUPs in the U.S., regardless of whether the MUPs are being sold in the U.S. or foreign markets.

### **6.3.3.2 Summary of the FIFRA Data Review**

From its review of PRISM and SSTS data, EPA confirmed that seven of the 30 PAIs are currently registered under FIFRA Section 3. Four of the seven registered PAIs are produced as MUPs at facilities in the U.S. In addition, EPA identified one PAI that has never been registered, but is produced as MUPs at U.S. establishments for export. Table 6-6 presents information on the eight PAIs that are currently registered under FIFRA Section 3 and/or included in MUPs produced in the U.S.

EPA has acknowledged the limitations of the databases from which this information was compiled. Neither the PRISM or SSTS databases provide information to indicate whether the identified establishments manufacture or formulate these PAIs. Additionally, the SSTS database may not be up-to-date and comprehensive, as it is not a required method of reporting. Therefore, the list of five PAIs that EPA identified as produced by U.S. establishments may not be a complete or fully accurate compilation of all PAIs potentially manufactured in the U.S.

Due to the limitations of the PRISM and SSTS databases discussed above, EPA OW also consulted with EPA OPP to understand if any of the unregistered PAIs are in exported MUPs. If a U.S. company exports an unregistered pesticide product (including MUPs and end-use products), they must submit a Foreign Purchaser Acknowledgement Statement (FPAS), which includes the CAS Numbers of any active ingredients in the products. EPA OPP searched the FPAS database by PAI CAS Number to find any exports of unregistered products since 2011. Consistent with the information presented in Table 6-6, OPP confirmed through FPAS records that the unregistered PAI Tokuthion is exported as MUPs to foreign markets, and that no other unregistered PAIs are exported in pesticide products.

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<sup>61</sup> EPA focused its review on the PAIs most likely manufactured in the U.S. because, as described in Section 6.3.1, 40 CFR Part 455 Subparts A and B regulate conventional pollutants, nonconventional pollutants (including some, but not all, PAIs), and priority pollutants from pesticide chemical manufacturers that manufacture PAIs. EPA notes that the formulating and packaging of PAIs are subject to zero discharge standards under Subparts C and E, unless the facility incorporates certain pollution prevention alternative practices.

*6—EPA’s Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

---

To gather more information on the PAIs that are registered and/or identified as being produced as MUPs in the U.S. (listed in Table 6-6), EPA consulted the OPPIN database to identify the registered intended use of each PAI in the U.S. When registered in the U.S., PAIs are designated for specific uses (OPPIN, 2016). Table 6-6 also provides the uses of the PAIs.

## 6—EPA's Continued Investigations of Pollutants and Treatment Technologies

## Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals Manufacturing Effluent Limitations (40 CFR Part 455)

**Table 6-6. FIFRA Information for Eight PAIs Registered and/or Included in MUPs Produced in U.S.**

PAI Name	CAS Number	Registration Status in PRISM Database	Pesticide Use	MUP Containing PAI registered in PRISM	Number of U.S. Establishments Producing MUP Containing PAI in SSTS	Export Status from the U.S.	Market
Chlorpyrifos methyl	5598-13-0	First registered in 1985; under registration review.	Insecticide	Yes	0	Exported	U.S. & Foreign
Coumaphos	56-72-4	First registered in 1958; under registration review.	Insecticide	Yes	3	Not exported	U.S.
Ethoprop	13194-48-4	First registered in 1967; under registration review.	Insecticide	Yes	2	Exported	U.S. & Foreign
Etridiazole	2593-15-9	First registered in 1962; under registration review.	Fungicide	Yes	3	Exported	U.S. & Foreign
Fenitrothion	122-14-5	First registered in 1975; under registration review. Only product registered in the U.S. is for formulating other insecticides. No end-use products registered in the U.S.	Insecticide	Yes	0	Not exported	U.S.
Fluometuron	2164-17-2	First registered in 1974; under registration review.	Herbicide	Yes	0	Not exported	U.S.
Oxamyl	23135-22-0	First registered in 1974; under registration review.	Insecticide	Yes	2	Exported	U.S. & Foreign
Tokuthion (Prothiofos)	34643-46-4	Never registered in the U.S.	Insecticide	No	2	Exported	Foreign

Sources: (OPP, 2016; OPPIN, 2016; U.S. EPA, 2016a, 2016b, 2016c)

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

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#### **6.3.4 DMR and TRI Data**

As part of the current review, EPA also reviewed available DMR and TRI data to evaluate if any of the five PAIs identified in Section 6.3.3 are present in industrial wastewater discharges. EPA searched recent DMR and TRI data for all five PAIs using parameter codes identified based on the PAI CAS Number (ERG, 2016).<sup>62</sup> The DMR and TRI data provide the most comprehensive source of information on current wastewater discharges in the U.S. However, neither dataset provides a comprehensive overview of the PAIs present in industrial wastewater discharges because the PAIs do not currently have PAI-specific effluent limitations for pesticide chemicals manufacturing under the Pesticide Chemicals ELGs. Thus, the five PAIs are included on DMRs only if the permitting authority has established a specific limit or monitoring requirement in the facility's permit. In addition, only a subset of PAIs are TRI-listed chemicals, for which facilities would be required to report releases under the TRI program. See Section 2.1 of this report for a general discussion of the usefulness and limitations of the DMR and TRI data and further details on the compiled data.

EPA reviewed 2010 through 2015 DMR data from facilities reporting any of the five PAIs. EPA also reviewed 2010 through 2015 DMR data from publicly owned treatment works (POTWs) reporting any of these five PAIs because POTWs may receive wastewater from an indirect discharging pesticide chemical manufacturer producing PAIs.

EPA also reviewed TRI reporting requirements and 2010 through 2015 TRI water release data. EPA identified that only one of the five PAIs, Ethoprop, is a TRI-listed chemical.

Table 6-7 summarizes the DMR and TRI data compiled for the five PAIs. Only one of these PAIs, Oxamyl, has reported discharges from three POTWs. EPA has not investigated whether POTWs with discharges containing PAIs originate from pesticide chemical manufacturing facilities or other sources such as pesticide use. From 2010 through 2015, no industrial facilities reported DMR or TRI discharges of the five PAIs. However, as previously discussed, the DMR and TRI datasets are limited. Therefore, the DMR and TRI discharges that EPA identified for the five PAIs may not be exhaustive.

Although EPA identified PAI discharges in the DMR and TRI datasets, EPA lacks sufficient information to tie these discharges to facilities manufacturing specific PAIs. In addition, discharges reported to DMR and TRI may result from packaging or formulating facilities or contamination present in the environment (e.g., pesticide use), which are not in the scope of discharges from pesticide chemical manufacturers addressed by the ELG.

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<sup>62</sup> A parameter code is a unique five-digit number code used in DMR and TRI data to specify each unique pollutant.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

**Table 6-7. Summary of DMR and TRI Data Collected for 2016 Review of the PAIs of Interest**

PAI Name	CAS Number	TRI 2010 through 2015		DMR 2010 through 2015	
		TRI Listed Chemical	Number of Facilities with Pollutant Load Greater Than Zero	Number of POTWs with Pollutant Load Greater Than Zero	Number of Non-POTWs with Pollutant Load Greater Than Zero
Coumaphos	56-72-4				
Ethoprop	13194-48-4	✓	0		
Etridiazole	2593-15-9				
Oxamyl	23135-22-0			3	0
Tokuthion (Prothiofos)	34643-46-4				

Source: (ERG, 2016)

### 6.3.5 Toxicology Data

The presence in the environment of PAIs identified in Section 6.3.3 may be due to the discharge of wastewater during their manufacture and/or during their formulation, or due to soil and groundwater contamination resulting from their use in nearby areas.

To understand the potential fate and transport of these PAIs in the environment, EPA compiled environmental fate information using the National Oceanic and Atmospheric Administration (NOAA) Chemical Aquatic Fate and Effects (CAFE) Database (NOAA, 2016a). Table 6-8 summarizes the environmental fate data for the five PAIs identified in Section 6.3.3. The chemical and physical parameters listed determine the tendency and extent of the environmental fate processes for each PAI.

Each chemical or physical parameter listed in Table 6-8 determines the environmental fate effects of the PAIs of interest. An explanation of each parameter is listed below.

- The *soil organic carbon-water partitioning coefficient (K<sub>oc</sub>)* is correlated to soil mobility, or the potential for chemicals to leach through soil and be introduced to groundwater. Lower values of K<sub>oc</sub> correspond to more mobility in soils, and higher K<sub>oc</sub> values corresponds to less mobility (NOAA, 2016b).
- The octanol/water partition coefficient (Log K<sub>ow</sub>) correlates to a chemical's polarity and partitioning to organic matter, with a higher Log K<sub>ow</sub> indicating a higher likelihood of partitioning into organic matter in soil, of absorbing into suspended sediments, and of bioconcentrating in organisms (NOAA, 2016b). Log K<sub>ow</sub> values less than 1 indicate high solubility in water; values 2-4 indicate moderate solubility and a tendency to absorb through skin; values greater than 4 are hydrophobic; and values greater than 5 tend to bioconcentrate in organisms' membranes (U.S. EPA, 2012b).
- Water solubility reflects the maximum amount of a chemical that will dissolve in pure water at a specified temperature.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

- Henry's Law Constant indicates a chemical's volatility from water, or its tendency to transition from the liquid phase to vapor. Values between  $10^{-3}$  and  $10^{-5}$  are moderately volatile from water; values between  $10^{-5}$  and  $10^{-7}$  are slightly volatile from water; and values less than  $10^{-7}$  are nonvolatile (U.S. EPA, 2012b).
- The vapor pressure is indicative of a chemical's volatility, with higher vapor pressure indicating higher volatility.

Environmental fate data are available for all five of the PAIs identified in Section 6.3.3. While the chemical and physical parameters for the PAIs may differ under varying environmental conditions, the environmental fate and transport data for some PAIs indicate tendencies to persist in the environment (Coumaphos, Tokuthion), mobilize to groundwater (Ethoprop, Etridiazole, Oxamyl), and bioconcentrate in organisms (Tokuthion).

**Table 6-8. Environmental Fate Data for PAIs of Interest**

		PAI Name				
		Coumaphos	Ethoprop	Etridiazole	Oxamyl	Tokuthion
CAS Number		56-72-4	13194-48-4	2593-15-9	23135-22-0	34643-46-4
<b>Chemical and Physical Parameters</b>						
Soil Organic Carbon-Water Partitioning Coefficient (K <sub>oc</sub> )		3,660	213	163	10	7,470
Octanol/Water Partition Coefficient (Log K <sub>ow</sub> )		4.13	3.59	3.37	-0.48	5.67
Water Solubility (mg/L)		1.5	750	117	280,000	0.07
Henry's Law Constant (atm-m <sup>3</sup> /mol)		3.10E-08	1.60E-07	2.80E-07	2.40E-10	3.01E-05
Vapor Pressure (mmHg)		9.70E-08	3.80E-04	1.00E-04	2.30E-04	9.40E-06
<b>Environmental Fate Processes</b>						
Soil	Mobility	Slight	Moderate	Moderate	Very High	None
	Expected to Volatilize	No	No	May from Moist Soil	No	May from Moist Soil
Water	Expected to Absorb into Suspended Solids and Sediment	Yes	No	No	No	Yes
	Expected to Volatilize	No	Yes	Yes	No	Yes
Air	Exist in Vapor Phase	No	Yes	Yes	Yes	Yes
	Exist in Particulate Phase	Yes	No	No	No	Yes

Source: (NOAA, 2016a)

EPA also compiled human health data for the five PAIs using the National Institute of Health National Library of Medicine Toxicology Data Network (TOXNET) database (HSDB, 2016). EPA compiled the carcinogenic and non-carcinogenic effects data available, summarized in Table 6-9. Human health data are available for the four registered PAIs, but not for Tokuthion (which is unregistered). Two of the four registered PAIs are probable carcinogens, and the other two may have serious respiratory, skin, eye, and nervous system human health effects.

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

**Table 6-9. Human Health Effects of PAIs of Interest (per TOXNET)**

	PAI Name				
	Coumaphos	Ethoprop	Etridiazole	Oxamyl	Tokuthion <sup>a</sup>
CAS Number	56-72-4	13194-48-4	2593-15-9	23135-22-0	34643-46-4
<b>Carcinogenic Effects</b>					
No Cancer Information					
Non-Carcinogenic	✓			✓	
Probable Carcinogen		✓	✓		
<b>Non-Carcinogenic Effects</b>					
Respiratory Problems	✓	✓		✓	
Skin Irritant	✓		✓	✓	
Eye Irritant	✓	✓	✓	✓	
Reproductive Problems					
Nervous System/Brain	✓			✓	
Nephrotoxic (Kidneys)					
Hepatotoxic (Liver)					
Circulatory/Heart				✓	
Nausea/Vomiting		✓		✓	
Convulsions	✓			✓	
Ataxia	✓				

Source: (HSDB, 2016)

<sup>a</sup> No human health data were provided in TOXNET.

### **6.3.6 Summary of EPA's Continued Targeted Review of PAIs Without Pesticide Chemicals Manufacturing Effluent Limitations**

EPA's 2012 Annual Review identified 30 PAIs of interest for which there are no PAI-specific effluent limitations under Subpart A in 40 CFR Part 455. During the 1993 pesticides chemicals ELG revisions, EPA identified 29 of the 30 PAIs of interest, but did not establish PAI-specific nonconventional pollutant limitations. EPA's 2014 targeted review of the Pesticide Chemicals Category identified seven of the 30 PAIs that are currently registered or are under registration review in accordance with FIFRA Section 3.

During the current review, EPA reviewed data in PRISM and SSTS and identified five PAIs that are potentially manufactured in the U.S., one of which is unregistered, but produced in the U.S. for export as MUPs. At this time, EPA is not able to conclude that this is a comprehensive list due to the limitations of the datasets reviewed. However, for the five PAIs potentially manufactured in the U.S., EPA identified the following:

- All five PAIs have approved analytical methods that exist under the CWA.
- There are no current numeric PAI-specific effluent limitations for pesticide chemicals manufacturing (under Subpart A).

*6—EPA's Continued Investigations of Pollutants and Treatment Technologies*  
*Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals*  
*Manufacturing Effluent Limitations (40 CFR Part 455)*

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- One of the PAIs potentially manufactured in the U.S. has a reported pollutant load in the DMR database, originating from three POTWs; no PAI discharges were reported from pesticide chemicals manufacturing facilities. However, the Pesticide Chemicals ELGs do not establish PAI-specific numeric limitations for the PAIs; therefore, facilities may not be required to report discharges of the PAIs on their DMRs.
- Only one of the PAIs potentially manufactured in the U.S. is a TRI-listed chemical, and it does not have a pollutant load reported to TRI from any facility within the last five years. However, facilities are not required to report discharges for non-TRI-listed chemicals.
- Environmental fate data are available for all five PAIs. Human health effects data are available for all but one of the five PAIs (Tokuthion, which is produced in the U.S. for export).

### **6.3.7 Pesticide Chemicals Category References**

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 Section 6.3—Continued Targeted Review of Pesticide Active Ingredients (PAIs) Without Pesticide Chemicals  
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*Appendix A:  
Evaluating Data Quality of Sources for the Effluent Guidelines Planning  
Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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**Appendix A:  
Evaluating Data Quality of Sources for the Effluent Guidelines Planning  
Review Report Supporting the Final 2016 Effluent Guidelines Program Plan**

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*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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## **Appendix A: Evaluating Data Quality Of Sources For The Effluent Guidelines Planning Review Report Supporting The Final 2016 Effluent Guidelines Program Plan**

### **A.1 Background**

For the current review, EPA continued preliminary category reviews of the Iron and Steel Manufacturing (40 CFR Part 420), Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) (40 CFR Part 414), and Pulp, Paper, and Paperboard (Pulp and Paper) (40 CFR Part 430) categories. For more information on these continued preliminary category reviews, see Section 4 of this report. Specifically, as part of its continued preliminary reviews of these categories, EPA:

- Reviewed historical documentation supporting the development of the effluent limitations guidelines and standards (ELGs).
- Evaluated available industrial wastewater discharge data, including discharge monitoring report (DMR) and Toxics Release Inventory (TRI) data.
- Contacted facilities to gather additional wastewater discharge data (including effluent concentrations) and to understand how process operations contribute to discharges.
- Contacted state permitting authorities to understand how they develop permit limits.
- Reviewed available National Pollutant Discharge Elimination System (NPDES) permit documentation for select facilities.
- Evaluated the performance of available treatment technologies for a subset of pollutants identified for further review.
- Reviewed data available in Canada's National Pollutant Release Inventory (NPRI) to identify potential additional pollutants that may be present in industrial wastewater discharges from these categories in the U.S.

EPA also continued its review of the Battery Manufacturing (40 CFR Part 461) and Electrical and Electronic Components (E&EC) (40 CFR Part 469) categories to further understand recent changes within the industries, and to identify potential new pollutants in industrial wastewater discharges that may not be adequately regulated by current ELGs. In addition, EPA reviewed miscellaneous food and beverage manufacturing sectors not currently regulated by national ELGs, to identify specific sectors that may require further review for the potential development of ELGs. For more information on these continued reviews, see Section 5 of this report. Specifically, for its reviews of Battery Manufacturing and E&EC, EPA:

- Reviewed historical documentation supporting the development of the ELGs.
- Evaluated available industrial wastewater discharge data, including DMR and TRI data.
- Reviewed available NPDES permit documentation for select facilities.
- Reviewed U.S. economic census data and other economic data (e.g., IBISWorld Industry Reports) to understand the status and current profile of the industry.

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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- Reviewed literature to gather information on current process operations, wastewater discharge practices, and treatment.
- Attended industry conferences and contacted industry trade associations and facilities to gather information on changes in the industry over time, and further understand current process operations, wastewater discharge practices, and treatment.

In addition, as part of the current review, EPA continued its review of several proposed actions identified in the *Final 2014 Effluent Guidelines Program Plan* (U.S. EPA, 2015), including (1) an investigation of the manufacture and processing of engineered nanomaterials (ENMs) as a potential new source of industrial wastewater discharge; (2) a review of industrial wastewater treatment technology data for inclusion in the Industrial Wastewater Treatment Technology (IWTT) Database; and (3) a targeted review of pesticide active ingredient (PAI) discharges not currently regulated under the Pesticide Chemicals ELGs (40 CFR Part 455). For more information on these reviews, see Section 6 of this report.

Specifically, for the investigation of the manufacture and processing of ENMs, EPA:

- Reviewed federal government publications on ENMs.
- Evaluated information obtained from the National Nanotechnology Initiative (NNI).
- Reviewed literature and attended industry conferences to gather information on ENM production, use, disposal, wastewater generation and treatment, analytical methods for ENM detection, and fate and transformation of ENMs in the environment.

For its review of industrial wastewater treatment technology data, EPA updated its continued review of industrial wastewater treatment technologies and the IWTT Database. The *Supplemental Quality Assurance and Control Plan for Development and Population of the Industrial Wastewater Treatment Technology Database* (ERG, 2013a) describes the IWTT data collection methods, data sources, data quality assurance and control criteria, and the plan for data storage. For this review, EPA attended and reviewed proceedings from technical conferences on wastewater treatment to gather additional information on wastewater treatment technology performance.

For its targeted review of PAI discharges that are not currently regulated under the Pesticide Chemicals ELGs, EPA:

- Reviewed historical documentation supporting the development of the Pesticide Chemicals ELGs.
- Reviewed Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) Section 3 and Section 7 data maintained by U.S. EPA Office of Pesticides Program.
- Reviewed other federal government and non-governmental organization databases regarding pesticide use, regulation, and toxicity.
- Evaluated available industrial wastewater discharge data, including DMR and TRI data.

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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For all of the analyses conducted as part of this review as described above, EPA collected data, evaluated their usefulness, and documented their usability and quality in accordance with the general specifications presented in the *Environmental Engineering Support for Clean Water Regulations Programmatic Quality Assurance Project Plan (PQAPP)* (ERG, 2013b).

EPA relied on TRI data and DMR data, downloaded from the Water Pollutant Loading Tool, as an integral component for most of the current review analyses. EPA documents the general quality assurance measures and criteria for DMR and TRI data in the *Revised Quality Assurance Project Plan for the 2009 Annual Screening-Level Analysis of TRI, ICIS-NPDES, and PCS Industrial Category Discharge Data* (ERG, 2009). EPA has documented the quality assurance measures and criteria of the Water Pollutant Loading Tool in Section 5 of the *Technical Users Background Document for the Discharge Monitoring Report (DMR) Pollutant Loading Tool* (U.S. EPA, 2012). Section 2.1 of this report describes in detail the methodology, utility, and limitations of the DMR and TRI data, as well as EPA's quality review, as they relate to the current review. Similarly, EPA relied on NPRI data to supplement the DMR and TRI data for a subset of its continued category reviews. Section 2.2 of this report describes in detail the methodology, utility, limitations of the NPRI data, as well as EPA's quality review as they relate to the current review.

The following sections provide more detailed information on EPA's evaluation of the data quality for all other data sources identified and used in this review.

## **A.2    Data Sources**

EPA used the following categories of data sources for its current review:

- Conference proceedings, peer-reviewed journals, other academic literature.
- State and local government information provided in telephone calls and emails.
- Federal, state, and local government publications.
- Data and information obtained from industry and trade associations.
- Other (non-government, non-industry) publications and databases.

## **A.3    Data Quality Criteria**

EPA used existing data to support analyses of the potential impact of industrial discharges on the environment. EPA obtained the existing data from government and other peer reviewed publications or databases, publicly available data, correspondence with industry and state and local governments, attending industry conferences, and online sources. EPA considered the accuracy, reliability, and representativeness of data sources to assess their usability for the current review, as described in Section 4.3.1 of the *Environmental Engineering Support for Clean Water Regulations PQAPP* (ERG, 2013b) and as expanded upon below. EPA also referenced Table 4-2 in the *Environmental Engineering Support for Clean Water Regulations PQAPP* to determine that the sources provided information that is sufficiently accurate and reliable for use in this review.

*Accuracy.* EPA assumed that the data and information contained in supporting government publications or databases, selected conference proceedings, peer-reviewed journal

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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articles, and other academic literature are sufficiently accurate to support the general and/or facility-specific characterization of industries, process operations, and waste streams. EPA considered the data and information obtained from direct correspondence with state and local government representatives and regulators, and data from federal government agencies as sufficiently accurate to characterize and quantify specific wastewater discharges or process operations from individual facilities. EPA considered data from industry, including discussions with trade association and correspondence with individual facilities sufficiently accurate to provide a qualitative characterization and understanding of industries, process operations, and waste streams. EPA considered government and other economic data sources (e.g., U.S. economic census data, IBISWorld Reports) to be sufficiently accurate and used them in profiling industries and analyzing market statistics.

*Reliability.* EPA used the following criteria to evaluate the reliability of available data and other information collected and used in its analyses:

- The scientific work is clearly written, so that all assumptions and methodologies can be identified.
- The variability and uncertainty (quantitative and qualitative) of the information or in the procedures, measures, methods, or models are evaluated and characterized.
- The assumptions and methods are consistently applied throughout the analysis, as reported in the source.
- Waste streams, parameters, units, and detection limits (when appropriate) are clearly characterized.
- The governmental or facility contact is reputable and has knowledge of the industry, facility, process operation, or waste streams of interest.

EPA considered data sources that met these criteria sufficiently reliable to characterize and understand industries, process operations, and waste streams.

*Representativeness.* EPA used the following criteria to evaluate whether the data and information provide a national perspective and are relevant to and representative of the industry to which the data are applied:

- *Relevance.* The data source is relevant to the industry or pollutant group of interest (e.g., the industry description or Standard Industrial Classification (SIC) and North American Industry Classification System (NAICS) codes provided in the data source, when available, match the industry; the Chemical Abstract Service (CAS) number matches the CAS number for the pollutant or interest).
- *National applicability.* The data can be applied broadly to provide a national perspective relative to the industry or pollutant group of interest (e.g., the data are characteristic of the industry or pollutant group as a whole).

EPA considered data sources that met these criteria sufficiently representative to characterize industries, process operations, and waste streams.

## **A.4 Evaluating Data Quality**

This section describes the data sources in more detail and how they met the evaluation criteria listed above. Table A-1 at the end of this section details the criteria applied and the conclusions reached on each data source.

### ***A.4.1 Conference Proceedings, Peer-Reviewed Journal Articles, Other Academic Literature***

EPA reviewed selected conference proceedings, peer-reviewed journal articles, and other academic literature in support of its reviews of Battery Manufacturing, E&EC, and ENMs. EPA applied the data quality criteria established in the *Environmental Engineering Support for Clean Water Regulations PQAPP* (ERG, 2013b) and determined that the data and information obtained from conference proceedings, peer-reviewed journals, and other academic literature were sufficiently accurate, reliable, and representative for process operations and waste streams associated with Battery Manufacturing, E&EC, and ENMs.

EPA is also collecting, reviewing, and compiling data on the performance of new or improved wastewater treatment technologies into a searchable IWTT Database. EPA obtained this industrial wastewater treatment technology data from conference proceedings, water-related journals, and literature from industry-specific organizations. For more information on EPA's efforts to ensure that the data sources included in the IWTT Database meet the data quality criteria, see the methodology documented in the *Supplemental Quality Assurance and Control Plan for the Development and Population of the Industrial Wastewater Treatment Technology Database* (ERG, 2013a).

### ***A.4.2 State and Local Government Information Provided in Telephone Calls and Email Correspondence***

In support of its continued reviews of the Iron and Steel, OCPSF, Battery Manufacturing and E&EC categories, EPA collected information through telephone calls and email correspondence with state and local government regulators and representatives regarding wastewater discharges from specific facilities. EPA considers information provided from such informal communications to be anecdotal, but useful for qualitative descriptions, such as general information on industrial sector trends, characterization of industrial wastewater discharges, and available industrial wastewater treatment technologies. From discussions with state and local government representatives, EPA often obtained published information such as NPDES permits and fact sheets; however, EPA evaluated the quality of this published information separately (see section A.4.3, Federal, State, and Local Government Publications, below).

### ***A.4.3 Federal, State, and Local Government Publications***

EPA reviewed federal, state, and local government publications related to its continued reviews of the Iron and Steel, OCPSF, Pulp and Paper, Battery Manufacturing and E&EC categories, and its targeted review of PAI discharges not currently regulated under the Pesticide Chemicals ELGs. These publications included regulations, U.S. Economic Census data, reports, government databases, and supporting documentation related to the specific industrial categories and pollutants of interest. EPA also reviewed state and local government publications, including NPDES permits and fact sheets. EPA used these publications to enhance its understanding of the impact of existing government programs and regulations on the industry or the pollutant group of

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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interest. Using the criteria established in the *Environmental Engineering Support for Clean Water Regulations PQAPP* (ERG, 2013b), EPA determined that data and information provided in government publications are sufficiently accurate and reliable to characterize specific wastewater discharges, process operations, waste streams, and pollutant loads and concentrations, and/or could be applied nationally to characterize general industrial sector trends or pollutant groups of interest.

#### ***A.4.4 Industry and Trade Association Information***

EPA obtained information from direct email or telephone communications with industry to support its continued reviews of the Iron and Steel, OCPSF, Pulp and Paper, Battery Manufacturing and E&EC categories. This included contacting specific facilities to obtain underlying concentration data used to calculate discharges reported to TRI as well as gathering information regarding facility-specific process operations and waste streams. EPA determined that data obtained directly from facility contacts regarding reported DMR or TRI data are sufficiently accurate, reliable, and representative to characterize the facility-specific wastewater discharges. EPA also obtained information from specific pulp and paper, battery manufacturing, and E&EC industry trade associations. This included descriptions of process operations, wastewater discharge practices, market statistics, potential pollutants of concern, wastewater characteristics, wastewater treatment technologies, and company profile information (e.g., types of products they produce). EPA applied the criteria established in the *Environmental Engineering Support for Clean Water Regulations PQAPP* (ERG, 2013b) and determined that this information was sufficiently accurate, reliable, and representative of the facilities of interest for use in characterizing industry sector trends and process operations that generate waste streams.

#### ***A.4.5 Non-Industry, Non-Government Publications and Databases***

EPA obtained information (such as economic trends) from other non-industry, non-government publications (e.g., IBISWorld) and data from other non-governmental organizations (e.g., Pesticide Action Network Pesticide Database), in support of its reviews of the Battery Manufacturing, E&EC, and Pesticide Chemicals categories. EPA applied the criteria established in the *Environmental Engineering Support for Clean Water Regulations PQAPP* (ERG, 2013b) and determined that this information was sufficiently accurate, reliable, and representative for use in understanding and characterizing industrial sector trends.

### **A.5 References for Quality Assurance Activities Supporting the ELG Planning Review Report Supporting the Final 2016 ELG Plan**

1. ERG. 2009. Eastern Research Group, Inc. *Revised Quality Assurance Project Plan for the 2009 Annual Screening-Level Analysis of TRI, ICIS-NPDES, and PCS Industrial Category Discharge Data*. Chantilly, VA. (September). EPA-HQ-OW-2008-0517-0507.
2. ERG. 2013a. Eastern Research Group, Inc. *Supplemental Quality Assurance and Control Plan for the Development and Population of the Industrial Wastewater Treatment Technology Database*. Chantilly, VA. (November 22). EPA-HQ-OW-2010-0824-0263.

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

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3.     ERG. 2013b. Eastern Research Group, Inc. *Environmental Engineering Support for Clean Water Regulations Programmatic Quality Assurance Project Plan (PQAPP)*. Chantilly, VA. (May). EPA-HQ-OW-2010-0824-0229.
4.     U.S. EPA. 2012. *Technical Users Background Document for the Discharge Monitoring Report (DMR) Pollutant Loading Tool Version 1.0*. Washington, D.C. (January). [http://cfpub.epa.gov/dmr/docs/Technical\\_Users\\_Background\\_Doc.pdf](http://cfpub.epa.gov/dmr/docs/Technical_Users_Background_Doc.pdf). EPA-HQ-OW-2014-0170-0203.
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*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

**Table A-1. Data Sources Supporting Analyses for EPA's Current Review**

Data Source	Data Quality Criteria		Conclusions on Usability
	Accuracy and Reliability	Representativeness	
Conference Proceedings, Peer-Reviewed Journal Articles, Other Academic Literature	Information is obtained from selected national conference proceedings, peer-reviewed journal articles, and other academic literature. All data sources are clearly written, document methodologies and assumptions, describe variability and uncertainty (where relevant), and characterize waste streams, parameters, units, and detection limits.	Data and information are relevant to the industry or pollutant group to which the data are applied. Data also provide general information about industrial sector trends (e.g., new products and process operations). EPA determined this information could be applied nationally to the relevant sectors or pollutants of interest.	EPA considers this type of data and information sufficiently accurate, reliable, and representative, and therefore, usable to characterize industry operations, waste streams, wastewater discharge practices, and wastewater treatment performance.
State and Local Government Information Provided in Telephone Calls and Email Correspondence	State and local government representatives provided information on wastewater discharges from specific facilities through telephone calls and email correspondence. EPA considers the information anecdotal, but sufficiently accurate and reliable for qualitative descriptions. EPA requested published or written information to support information provided from informal communication, when available.	Data and information are relevant to the industry to which the data are applied. Though the information gathered from state and local government representatives was generally facility-specific (e.g., verification of facility wastewater discharge data and process operations), EPA determined that the information, when considered collectively, could be applied nationally to facilitate EPA's understanding of the category as a whole.	<p>EPA considers this type of information anecdotal, but sufficiently accurate, reliable, and representative for characterizing facility-specific operations and discharges. EPA also considers this information useful for facilitating its understanding of category-wide industrial sector trends, wastewater discharges, and available wastewater treatment technologies.</p> <p>EPA evaluates the quality of any published documents from state or local governments separately (see Federal, State, and Local Government Publications, below).</p>

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

**Table A-1. Data Sources Supporting Analyses for EPA's Current Review**

Data Source	Data Quality Criteria		Conclusions on Usability
	Accuracy and Reliability	Representativeness	
Federal, State, Local Government Publications	<p>EPA assumes that all data provided in federal, state, or local government reports and regulations are sufficiently accurate and reliable.</p> <p>All reports, regulations, and supporting documentation are clearly written and document methodologies and assumptions.</p>	<p>EPA verified the representativeness of the data to the industrial sectors of interest using industry descriptions, or, when available, applicable SIC or NAICS codes provided in the supporting documentation.</p> <p>All federal government reports, regulations, and supporting documentation provide a national perspective related to the industry to which the data are applied. Though the information gathered from state and local government representatives was generally facility-specific (e.g., verification of facility wastewater discharge data and process operations), EPA determined that the information, when considered collectively, could be applied nationally to facilitate EPA's understanding of the category as a whole.</p>	<p>EPA considers this type of data sufficiently accurate, reliable, and representative, and therefore usable to support industry and waste stream characterization, and for estimating pollutant discharges.</p>

*Appendix A:*  
*Evaluating Data Quality of Sources for the Effluent Guidelines Planning*  
*Review Report Supporting the Final 2016 Effluent Guidelines Program Plan*

**Table A-1. Data Sources Supporting Analyses for EPA's Current Review**

Data Source	Data Quality Criteria		Conclusions on Usability
	Accuracy and Reliability	Representativeness	
Industry and Trade Association Information	<p>EPA considers information obtained from industry and trade associations to be less certain than peer-reviewed information; however, EPA determined this information was sufficiently accurate and reliable for characterizing industry trends and operations. All industry data and information was obtained from known industry sources (e.g., directly from facility contacts, from industry trade association, or from company websites).</p> <p>EPA considers information regarding reported DMR or TRI data obtained directly from facility contacts to be accurate and reliable for characterizing facility-specific wastewater discharges and estimating facility-specific discharges.</p>	<p>EPA verified the representativeness of the data to the industrial sectors of interest using industry descriptions, or, when available, applicable SIC or NAICS codes provided in the supporting documentation.</p> <p>Although much of the information obtained from industry was facility or company-specific, EPA determined it was representative of, and useful for, facilitating EPA's understanding of the category as a whole.</p>	EPA considers this type of data sufficiently accurate, reliable, and representative, and therefore usable for characterizing industrial sector trends, process operations, and waste streams.
Other Non-Industry, Non-Government Publications and Databases	EPA considers information obtained from non-industry, non-government, non-peer reviewed sources (such as economic trends) to be less certain, but useful for the general industry. All non-industry information was obtained from known sources (e.g., IBISWorld, Pesticides Action Network).	EPA verified the representativeness of the data to the industrial sectors or pollutants of interest using industry descriptions, or, when available, applicable SIC or NAICS codes or CAS numbers provided in the supporting documentation.	Data are sufficiently accurate, reliable, and representative to use for generally characterizing industrial sector trends (new products or processes).

*Appendix B:  
Keyword Search Lists for Literature Reviews of  
Additional Point Source Categories*

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**Appendix B:  
Keyword Search Lists for Literature Reviews of  
Additional Point Source Categories**

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*Appendix B:  
Keyword Search Lists for Literature Reviews of  
Additional Point Source Categories*

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## **Appendix B: Keyword Search Lists for Literature Reviews of Additional Point Source Categories**

### **Keyword Search Terms for Battery Manufacturing Category Literature Review**

#### **Product Master Terms**

Battery Manufacturing  
Effluent  
Process  
Rechargeable  
Wastewater  
Discharge  
Electric vehicle  
Hybrid vehicle  
Renewable Energy Storage  
Microgrids  
Small grids  
SunShot Initiative Program (DOE)

#### **Product Specific Terms**

Anode  
Cathode  
Electrode  
Lithium anode  
Lithium ion  
Lithium manganese oxide  
Nickel-cadmium  
Nickel-hydrogen  
Nickel-metal hydroxide  
Vanadium redox  
(Electrochemical) Cell  
Electrolyte  
Terminals  
Current Collector (support/grid)  
Activator  
Separator  
Flow Battery

#### **Process Master Terms**

Fabrication  
Production  
Assembly  
Wash/Washing/Rinsing  
Ancillary operations  
Curing  
Amalgamation  
Manufacture  
Formulation  
Casting  
Rolling  
Coating

#### **Process Specific Terms**

Wet air pollution control (wet scrubbers)  
Paste Preparation  
Electrolyte Oxidation  
Equipment/floor/truck/laundry/personnel  
Direct Chill Casting  
Chemical reduction/oxidation  
Closed/Open Formation  
Plate Processing (Hydrosetting)  
Plate Soaking  
Wet/Dry Formation  
Mold release  
Counter current rinsing vs  
single flowing rinse  
Electrodeposition/Electrophoretic  
deposition/electroplating

*Appendix B:*  
*Keyword Search Lists for Literature Reviews of*  
*Additional Point Source Categories*

## **Keyword Search Terms for Electrical and Electronic Components**

### **Category Literature Review**

#### **Master Terms**

Electrical and electronic components  
 Industrial Wastewater  
 Industrial Wastewater Treatment  
 Metals Removal  
 Publicly owned treatment works (POTW)

#### **General Terms**

Effluent  
 Elimination  
 Influent  
 Percent (%)  
 Performance  
 Recovery/recycle  
 Reduce/reduction  
 Removal (efficiency)

#### **Industry Operations**

Cathode ray tube  
 Crystal wafers  
 Electronic crystals  
     Piezoelectric crystals  
     Lithium niobate  
     Sapphire crystals  
     Liquid crystals  
 Electronic devices  
 Luminescent Materials  
 Semiconductors  
 Solid state electrical devices

#### **Process Operations and Products**

Chemical Mechanical Planarization (CMP)  
 Sapphire Crystal Formation  
     Czochralski Method  
     Gradient Solidification  
     Heat Exchanger Method  
     Edge-Defined Film-Fed Growth (EFG)  
     Kyropoulos Method  
     Verneuil Flame-fusion Crystal Growth  
 Electron tube manufacturing  
 Gallium arsenic  
 Gallium phosphide wafers  
 Germanium wafers  
 Light emitting diode (LED)  
 Liquid crystal display device (LCD)  
 Polishing  
     Nano diamonds  
     Nanomaterials  
 Silicon based integrated circuits  
 Silicon wafers  
 Wafer diode  
 Wafer lapping  
 Wafer grinding  
 Hard drives  
 Lasers  
 Optical Applications  
 Silicon-on-sapphire microprocessors  
 Smartphone manufacturing  
 Sapphire boule  
 Solar cells

*Appendix C:*  
*Bibliography of Articles Entered into IWTT*

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<b>Title</b>	<b>Document Type</b>	<b>Author(s)</b>	<b>Date</b>	<b>Journal or Publisher</b>	<b>Page Count</b>	<b>Industry</b>
A Pilot Study of the Treatment of Waste Rolling Emulsion Using Zirconia Microfiltration Membranes	Peer-reviewed journal	Pei Wang, Nanping Xu, Jun Shi	2000	Journal of Membrane Science	8	Metal finishing
Nitrogen and DOC Removal from Wastewater Streams of the Metal-working Industry	Peer-reviewed journal	R. Schuch, R. Gensicke, K. Merkel, J. Winter	2000	Water Research	9	Metal finishing
Treatment of Rinsing Water from Electroless Nickel Plating with a Biologically Active Moving-bed Sand Filter	Peer-reviewed journal	T. Pumpel, C. Ebner, B. PernfuB, F. Schinner, L. Diels, Z. Keszthelyi, A. Stankovic, J.A. Finlay, L.E. Macaskie, M. Tsezos, H. Wouters	2001	Hydrometallurgy	11	Metal finishing
Optimization of Oily Wastewater Membrane Bioreactor Treatment: Pilot to Full Scale Results	Conference proceeding	Paul M. Sutton, Prakash N. Mishra, Jeff A. Roberts, Luis Abreu, Paul Gignac	2001	WEFTEC	24	Metal finishing
Reverse Osmosis Applied to Metal Finishing Wastewater	Peer-reviewed journal	Y. Benito, M.L. Ruiz	2002	Desalination	6	Ferroalloy manufacturing
A Pilot Study on a Membrane Process for the Treatment and Recycling of Spent Final Rinse Water from Electroless Plating	Peer-reviewed journal	F.S. Wong, J.J. Qin, M.N. Wai, A.L. Lim, M. Adiga	2002	Separation and Purification Technology	11	Metal finishing
Microsand Ballasted Flocculation and Clarification: Effects on Removal of TSS, Oil & Grease, and Metals from a Steel Mill Waste Stream	Conference proceeding	Carol Kessler, Luke Wood, Joe Gober, Barry Hendley	2002	WEFTEC	16	Iron and steel manufacturing
Heavy Metals Removal by Sand Filters Inoculated with Metal Sorbing and Precipitating Bacteria	Peer-reviewed journal	L. Diels, P.H. Spaans, S. Van Roy, L. Hooyberghs, A. Ryngaert, H. Wouters, E. Walter, J. Winters, L. Macaskie, J. Finlay, B. Pernfuss, H. Woebking, T. Pumpel, M. Tsezos	2003	Hydrometallurgy	7	Nonferrous metals manufacturing
Treatment of Oily Wastes by Membrane Biological Reactor	Conference proceeding	Jim Buckles, Art Kuljian, Kevin Olmstead, Jason Merritt	2003	WEFTEC	13	Metal finishing

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NF and RO Membranes for the Recovery and Reuse of Water and Concentrated Metallic Salts from Waste Water Produced in the Electroplating Process	Peer-reviewed journal	Jasmine Castelblanque, Francesco Salimbeni	2004	Desalination	9	Metal finishing
A Pilot Study for Reclamation of a Combined Rinse from a Nickel-plating Operation Using a Dual-membrane UF/RO Process	Peer-reviewed journal	Jian-Jun Qin, Maung Nyunt Wai, Maung Htun Oo, Hsiaowan Lee	2004	Desalination	13	Metal finishing
Metal Recovery from Electroplating Wastewater Using Acidophilic Iron Oxidizing Bacteria: Pilot-Scale Feasibility Test	Peer-reviewed journal	Donghee Park, Dae Sung Lee, Jong Moon Park, Hee Dong Chun, Sung Kook Park, Ikuro Jitsuhara, Osamu Miki, Toshiaki Kato	2005	Industrial & Engineering Chemistry Research	6	Metal finishing
Physical/Chemical Treatment for Refinery Wastewater	Conference proceeding	William Conner, Mohammed Al Hajri, John Liu	2005	WEFTEC	25	Petroleum refining
The Use of Liquid-Liquid Extraction for Heavy Metals Recovery and Reuse from Plating Wastewaters	Conference proceeding	Paul Usinowicz, Bruce Monzyk, H. Nicholas Conkle, J. Kevin Rose, Satya Chauhan	2005	WEFTEC	11	Metal finishing
Pilot Study on the Treatment of Spent Solvent Cleaning Rinse in Metal Plating	Peer-reviewed journal	Jian-Jun Qin, Maung Htun Oo, Fook-Sin Wong	2006	Desalination	6	Metal finishing
Biologically produced sulphide for purification of process streams, effluent treatment and recovery of metals in the metal and mining industry	Peer-reviewed journal	Jacco L. Huisman, Gerard Schouten, Carl Schultz	2006	Hydrometallurgy	8	Ore mining and dressing
Electrochemical Treatment Applied to Food-Processing Industrial Wastewater	Peer-reviewed journal	Carlos Barrera-Díaz, Gabriela Roa-Morales, Liliana Avila-Cordoba, Thelma Pavon-Silva, Bryan Bilyeu	2006	Industrial & Engineering Chemistry Research	5	Non-classifiable establishments
Treatment of High-Strength Pharmaceutical Wastewater and Removal of Antibiotics in Anaerobic and Aerobic Biological Treatment Processes	Peer-reviewed journal	Ping Zhou, Chengyi Su, Binwei Li, Yi Qian	2006	Journal of Environmental Engineering	8	Pharmaceutical manufacturing
Copper Recovery and Spent Ammoniacal Etchant Regeneration Based on Hollow Fiber Supported Liquid Membrane Technology: From Bench-scale to Pilot-scale Tests	Peer-reviewed journal	Qian Yang, N.M. Kocherginsky	2006	Journal of Membrane Science	9	Metal finishing

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Performance of an Up-flow Anaerobic Stage Reactor (UASR) in the Treatment of Pharmaceutical Wastewater Containing Macrolide Antibiotics	Peer-reviewed journal	Shreeshivadasan Chelliapan, Thomas Wilby, Paul J. Sallis	2006	Water Research	10	Pharmaceutical manufacturing
Three Years of Full-Scale Treatment of an Oily Wastewater Using an Immersed Membrane Biological Reactor	Industry publication	Jim Buckles, Art Kuljian, Kevin Olmstead, Tom Galloway	2007	WEFTEC	12	Transportation equipment cleaning
Application of struvite precipitation in treating ammonium nitrogen from semiconductor wastewater	Peer-reviewed journal	Hong-Duck Ryu, Daekeun Kim, Sang-Il Lee	2008	Journal of Hazardous Materials	7	Electrical and electronic components
Twofold Solution	Industry publication	George Patrick, Don Deemer, Loren McCune, Terry Snell	2008	WEF Industrial Wastewater	5	Aluminum forming
Tough Treatment Technology Membrane Bioreactors Can Handle Wastewater with Very High Salt, Chloride, and Total Dissolved Solids Levels	Industry publication	Joseph Lala, Shannon R. Grant, and Scott J. Christian	2008	WEF Industrial Wastewater	6	Miscellaneous foods and beverages
No Spikes: Allowed Better Chemical Feed Controls Eliminate Unwanted Effluent Spikes	Industry publication	Allan Erickson	2008	WEF Industrial Wastewater	4	Meat and poultry products
Best Arsenic Technology: A Power-generating Facility Upgrades its Wastewater Treatment System to Meet Stricter Limits	Industry publication	Jean-Claude Younan, Joseph Chwirka	2008	WEF Industrial Wastewater	6	Steam electric power generating
Enhancing Nitrification in an Oil Refinery WWTP with IFAS	Conference proceeding	Wayne J. Flournoy, Russ Grillo, Sarah B. Hubbell, Ramesh Kalluri, Casey Mueller	2008	WEFTEC	9	Petroleum refining
Aquatic Toxicity Reduction and Water Reuse at a Metal Finishing Plant	Conference proceeding	George Patrick, Don Deemer, Loren McCune, Terry Snell	2008	WEFTEC	12	Aluminum forming
Footprint and O&M Cost Reductions with Actiflo System - A Pilot Study for Gold Mining Effluent Treatment	Conference proceeding	Zhifei Hu, Brian Edwards, Jes Alexant, Jamie Quesnel	2008	WEFTEC	10	Ore mining and dressing
Application of bioaugmentation to improve the activated sludge system into the contact oxidation system treating petrochemical wastewater	Peer-reviewed journal	Fang Ma, Jing-bo Guo, Li-jun Zhao, Chein-Chi Chang, Di Cui	2009	Bioresource Technology	6	Organic chemicals, plastics and synthetic fibers

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Treatment of Beverage Production Wastewater by Membrane Bioreactor	Peer-reviewed journal	Marin Matošić, Ivana Prstec, Helena Korajlija Jakopović, Ivan Mijatović	2009	Desalination	9	Miscellaneous foods and beverages
Treatment of Textile Wastewater with an Anaerobic Fluidized Bed Reactor	Peer-reviewed journal	Mahdi Haroun, Azni Idris	2009	Desalination	10	Textile mills
Novel Single Stripper with Side-Draw to Remove Ammonia and Sour Gas Simultaneously for Coal-Gasification Wastewater Treatment and the Industrial Implementation	Peer-reviewed journal	Dachun Feng, Zhenjiang Yu, Yun Chen, Yu Qian	2009	Industrial & Engineering Chemistry Research	8	Oil and gas extraction
A Powerful Challenge: Treatment Plant Upgrade Aims to Minimize Electrical Conductivity While Nearly Doubling Capacity	Industry publication	James C. Young, Madan Arora, Lewis Nelson, and Richard Bono	2009	Industrial Wastewater	7	Non-classifiable establishments
Just Plane Better: Water Reuse Improves Aircraft Washing Operations at Texas Military Base	Industry publication	Richard Milhollon, Greg Braddy, Thomas Coffey, and Bill Morgan	2009	Industrial Wastewater	3	Airport deicing
Manage Water Better: Membrane Bioreactors Can Help Companies Make the Most of Their Water Resources	Industry publication	Jeff Peeters, Andrew Sparkes, Sven Baumgarten	2009	Industrial Wastewater	3	Grain mills
Manage Water Better: Membrane Bioreactors Can Help Companies Make the Most of Their Water Resources	Industry publication	Jeff Peeters, Andrew Sparkes, Sven Baumgarten	2009	Industrial Wastewater	3	Miscellaneous foods and beverages
Sludge Handling and Processing: A Taste for BOD5 Removal	Industry publication	Chandler Johnson, Neil McAdam	2009	Industrial WaterWorld	3	Miscellaneous foods and beverages
Transforming CBM Produced Water into a Valuable Resource	Industry publication	Juzer Jangbarwala	2009	Industrial WaterWorld	3	Oil and gas extraction
Selenium Removal from Refinery Wastewater via Iron Co-precipitation in a Mobile Clarifier	Conference proceeding	Charles McCloskey, Tom Jettinghoff	2009	Microconstituents /Industrial Water quality	7	Petroleum refining
Treatment of Metal Finishing Wastewater from Aircraft Maintenance Operations Using an Electrocoagulation Treatment Process	Conference proceeding	Forough Firouzi, Mark Ross, Gordon Champneys, Michael McFarland	2009	Microconstituents /Industrial Water Quality	8	Metal finishing

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Too Many Causes	Industry publication	Naomi Jones, Adam Smith, Gang Xin	2009	WEF Industrial Wastewater	6	Non-classifiable establishments
Quenching the Thirst in China	Industry publication	Angela Yeung, Robert Chu, Steven Rosenberg, and Thomas Tong	2009	WEF Industrial Wastewater	5	Iron and steel manufacturing
Mix It Up: A Gas-energy Mixing System Helps Improve Moving-bed Biofilm Reactor Performance	Industry publication	Miroslav Colic, Wade Morse, Ariel Lechter, Jason Hicks, Steve Holley, Carl Mattia	2009	WEF Industrial Wastewater	7	Meat and poultry products
Easy Upgrade: A Membrane Bioreactor Enables a Meat Processor to Upgrade its Wastewater Treatment System with Little Fuss	Industry publication	Ralph Teckenberg, Sandra Schuler, Andreas Böhm, Torsten Hackner, Markus Roediger	2009	WEF Industrial Wastewater	4	Meat and poultry products
Two Fine Fluids: A Membrane Bioreactor Treats Winery Wastewater Effectively and Leaves More Room for Grapes	Industry publication	Anu Shah, John Bulleri, Richard Ross, John Carter, Michael Long	2009	WEF Industrial Wastewater	6	Miscellaneous foods and beverages
Liquid-Liquid Extraction for Acid Mine/Acid Rock Drainage Processing for Water Purification and Recovery of Sulfate Metals Without Sludge or Brine Production	Conference proceeding	Paul Usinowicz, Bruce Monzyk, H. Nicolas Conkle, F. Michael VonFahnestock, Todd Beers	2009	WEFTEC	16	Coal mining
Treatment of Metal Finishing Wastewaters in the Presence of Chelating Substances	Conference proceeding	Forough Firouzi, Mark Ross, Gordon Champneys, Michael McFarland	2009	WEFTEC	6	Metal finishing
Innovative Technology for Biological Nitrification-Denitrification of Oil Refinery Wastewaters	Conference proceeding	Carl E. Adams, Jr., Ryan Kirkland, John D. Driver, Andrew W. Edwards	2009	WEFTEC	20	Petroleum refining
Lessons Learned on Long-Term Operation of MBBR for Refinery Wastewater Treatment	Conference proceeding	Christian Cabral, Eoin Syron, Ray C. Asencio, Chandler Johnson	2009	WEFTEC	16	Petroleum refining

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Pilot Testing and Modeling of a Membrane Biological Reactor System for Refinery Wastewater	Conference proceeding	Mauro Marinetti, Carlo Zaffaroni, Glen T. Daigger, Silas Givens, Ronald Ballard, C. P. Leslie Grady Jr., Savas Soydaner	2009	WEFTEC	20	Petroleum refining
Water Reuse in an Oil Refinery: An Innovative Solution Using Membrane Technology	Conference proceeding	Boris Ginzburg, Ross Cansino	2009	WEFTEC	11	Petroleum refining
Innovative Approaches to Complying with Very Low National Pollutant Discharge Elimination System (NPDES) Permit Limits for Metals	Conference proceeding	William Payne	2009	WEFTEC	13	Inorganic chemicals manufacturing
Innovative Approaches to Complying with Very Low National Pollutant Discharge Elimination System (NPDES) Permit Limits for Metals	Conference proceeding	William Payne	2009	WEFTEC	13	Non-classifiable establishments
Pilot-scale Removal of Chromium from Industrial Wastewater Using the ChromeBac System	Peer-reviewed journal	Wan Azlina Ahmad, Zainul Akmar Zakaria, Ali Reza Khasim, Muhamad Anuar Alias, Shaik Muhammad Hasbulla Shaik Ismail	2010	Bioresource Technology	8	Metal finishing
A Full-scale Biological Treatment System Application in the Treated Wastewater of Pharmaceutical Industrial Park	Peer-reviewed journal	Ge Lei, Hongqiang Ren, Lili Ding, Feifei Wang, Xingsong Zhang	2010	Bioresource Technology	10	Pharmaceutical manufacturing
TDS Removal in Wastewater Using Roughing Filters	Peer-reviewed journal	O I Nkwonta, G M Ochieng	2010	Chemical Sciences Journal	6	Coal mining
Process Development, Simulation, and Industrial Implementation of a New Coal-Gasification Wastewater Treatment Installation for Phenol and Ammonia Removal	Peer-reviewed journal	Zhenjiang Yu, Yun Chen, Dachun Feng, Yu Qian	2010	Industrial & Engineering Chemistry Research	8	Oil and gas extraction
What Nitrate?	Industry publication	Carl Adams Jr, Ryan Kirkland, John Driver, Andrew Edwards, Ruth Cade, Chad Louque, Wally Dows	2010	Industrial Wastewater	6	Petroleum refining

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Ultrafiltration and RO Treatment Consolidates Water Treatment Process for Indian Refinery	Industry publication	Unknown	2010	Industrial Wastewater	2	Petroleum refining
Biological Treatment Helps Remove Nitrate, Sulfate from Mine Runoff	Industry publication	Mark Reinsel	2010	Industrial WaterWorld	2	Coal mining
Treatment System Extracts Value from Acid Mine Drainage	Industry publication	Unknown	2010	Industrial WaterWorld	1	Coal mining
Historic Mine Uses Ion Exchange for Copper, Cobalt Removal	Industry publication	Paul Egder, Adam Szczesniak, Mark Korzenecki	2010	Industrial WaterWorld	2	Ore mining and dressing
Zero Liquid Discharge Installation is the First Permit-Free Chromium Plating Operation	Industry publication	David Delasanta	2010	Industrial WaterWorld	2	Metal finishing
Turnkey Treatment System Tackles Food-Processing Wastewater	Industry publication	Unknown	2010	Industrial WaterWorld	2	Canned and preserved fruits and vegetables processing
Heavy metal removal from industrial effluents by sorption on cross-linked starch: Chemical study and impact on water toxicity	Peer-reviewed journal	Bertrand Sancey, Giuseppe Trunfio, Jérémie Charles, Jean-François Minary, Sophie Gavaille, Pierre-Marie Badot, Grégorio Crini	2010	Journal of Environmental Management	8	
Use of Ozone in a Pilot-Scale Plant for Textile Wastewater Pre-treatment: Physico-chemical Efficiency, Degradation By-products Identification and Environmental Toxicity of Treated Wastewater	Peer-reviewed journal	Cleder A. Somensi, Edésio L. Simionatto, Sávio L. Bertoli, Alberto Wisniewski Jr., Claudemir M. Radetski	2010	Journal of Hazardous Materials	6	Textile mills
Stripping Cleans Up: Research on the stripping performance of wastewater containing high-concentration ammonia-nitrogen and zinc from a refinery plant	Industry publication	Jiang Linshi, Li Wei, Ma Hongfei, Li Na	2010	Pollution Engineering	4	Petroleum refining
Wastewater Helps Run Your Car	Industry publication	Dr. Marcus Allhands	2010	Pollution Engineering	1	Organic chemicals, plastics and synthetic fibers

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A Carbonless, Total Nitrogen Removal Process	Industry publication	Chandler Johnson	2010	Pollution Engineering	4	Non-classifiable establishments
Characterization and Treatment of Selenium in Water Discharged from Surface Coal Mining Operations in West Virginia	Conference proceeding	T. Harrison, T. Sandy, K. Leber, R. Srinivasan, J. McHale, J. Constant	2010	SME Annual Meeting	5	Coal mining
Suitable for Reuse	Industry publication	Elisângela Schneider, Ana Cláudia Figueiras Pedreira de Cerqueira, Geraldo Sant'Anna Jr., Marcia Dezotti	2010	WEF Industrial Wastewater	4	Petroleum refining
Needs More Work	Industry publication	Forough Firouzi, Mark A. Ross, Gordon Champneys, Michael J. McFarland	2010	WEF Industrial Wastewater	3	Metal finishing
Clear Results: Magnetic Ion Exchange Could Enable Pulp and Paper Mills to Reuse More Water.	Industry publication	Michael Bourke and Abigail Holmquist	2010	WEF Industrial Wastewater	4	Pulp, paper and paperboard
Food Wastes? No Problem! Full-scale Anaerobic Membrane Bioreactor Proves it Can Handle High-Strength Industrial Wastewater	Industry publication	Scott Christian, Shannon Grant, Dwain Wilson, Peter McCarthy, Dale Mills, Mike Kolakowski	2010	WEF Industrial Wastewater	4	Canned and preserved fruits and vegetables processing
High Strength? No Problem: Variable, High-strength Wastewater Not a Problem for Static Granular Bed Reactors	Industry publication	Jaeyoung Park, Michael F. Lally, Jin Hwan Oh, Timothy G. Ellis	2010	WEF Industrial Wastewater	7	Meat and poultry products
A Coordinated Approach to Achieving NPDES Permit Compliance for Mercury and Selenium in a Refinery Effluent	Conference proceeding	Greg Pulliam, Anthony Congram, Hal Davis, Bob Davis, Patricia Nelson	2010	WEFTEC	16	Petroleum refining
Evaluation of Activated Sludge Microfiltration for Refinery Wastewater Reuse	Conference proceeding	Christian Cabral, Erica Blumenschein, Carla Robinson	2010	WEFTEC	18	Petroleum refining
Wastewater Reuse Considerations at a Petroleum Refinery	Conference proceeding	Lucy Pugh, Alan Burghart, Carl Finlay	2010	WEFTEC	16	Petroleum refining
NPDES #WV1003763, Outlet #2 Selenium Treatment System Evaluation Report	Industry publication	Coal Mac, Inc.	2011	Consent Decree Report	3	Coal mining

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Application of membrane technology on semiconductor wastewater reclamation: A pilot-scale study	Peer-reviewed journal	C.J. Huang, B.M. Yang, K.S. Chen, C.C. Chang, C.M. Kao	2011	Desalination	8	Electrical and electronic components
High Recovery Reverse Osmosis for Treatment of Produced Water	Industry publication	Bob Kimball, Ken Klinko	2011	Industrial WaterWorld	2	Oil and gas extraction
Desalinating Produced Water for Beneficial Re-Use	Industry publication	Lnsn Nagghappan	2011	Industrial WaterWorld	3	Oil and gas extraction
Sulfate Removal from Acid Mine Drainage for Potential Water Re-use	Conference proceeding	Alex West, David Kratochvil, Phil Fatula	2011	IWC	15	Mineral mining and processing
Sulfate Removal from Acid Mine Drainage for Potential Water Re-use	Conference proceeding	Alex West, David Kratochvil, Phil Fatula	2011	IWC	15	Ore mining and dressing
Absorbent Technology for Removal of Soluble Mercury at the Trace Contaminant Level (Low Part Per Trillion)	Conference proceeding	Gina Sacco, Cheryl Soltis-Muth	2011	IWC	10	Centralized waste treatment
Enzymatic Removal of Selenocyanate from Sour Water Stripper Bottoms	Conference proceeding	Greg DeLozier, Ph.D., Yakup Nurdogan, Ph.D., P.E.	2011	IWC	9	Petroleum refining
Case Study on Selenium Removal from a Combined FGD Wastewater and Landfill Leachate for a Power Plant on the Ohio River	Conference proceeding	Michael Soller, PE, CPC; James Harwood; Tim Pickett	2011	IWC	12	Steam electric power generating
Demonstration Test of Iron Addition to a Flue Gas Desulfurization (FGD) Absorber to Enhance Flue Gas Selenium Removal	Conference proceeding	Thomas E. Higgins, Karen Meade, Denis Fink	2011	IWC	14	Steam electric power generating
Evaluation of Carbon Sources for the Anaerobic Treatment of Flue Gas Desulfurization (FGD) Wastewaters for Heavy Metals Removal	Conference proceeding	Antonio O. Lau, Rudy Labban, Sunil Mehta, A. Paul Togna	2011	IWC	16	Steam electric power generating
Organic Removal with Granular Activated Carbon (GAC) from Distillate Water with Bio-Fouling Tendency, and associated issues: A Follow-up Report on a Power Plant Case-Study	Conference proceeding	Emmanuel Quagraine	2011	IWC	26	Steam electric power generating
In Search of the Highest Purity Ion Exchange Resin Available Stretching the Limit of Microelectronics	Conference proceeding	Alan Knapp, Slava Libman	2011	IWC	10	Electrical and electronic components

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Anti-Fouling Membrane System for Industrial Wastewater Treatment and Recovery	Conference proceeding	Joon Min, Daeik Kim, Yong Eum, Gi T. Park, Sang W. Kim, Jang K. Kim, Dae H. Rhu	2011	IWC	11	Miscellaneous foods and beverages
Anti-Fouling Membrane System for Industrial Wastewater Treatment and Recovery	Conference proceeding	Joon Min, Daeik Kim, Yong Eum, Gi T. Park, Sang W. Kim, Jang K. Kim, Dae H. Rhu	2011	IWC	11	Oil and gas extraction
Anti-Fouling Membrane System for Industrial Wastewater Treatment and Recovery	Conference proceeding	Joon Min, Daeik Kim, Yong Eum, Gi T. Park, Sang W. Kim, Jang K. Kim, Dae H. Rhu	2011	IWC	11	Organic chemicals, plastics and synthetic fibers
Using Permeate Suction to Reduce Concentration Polarization in Spiral Wound Nanofiltration Module	Conference proceeding	Awad El-Shamy, Robert Carnahan, Mahmoud Nachabe, Mark Ross, Ayden Sunol, Ahmed Said	2011	IWC	11	Non-classifiable establishments
Recovery and Recycling of Industrial Side-stream Wastewater	Conference proceeding	Michael Chan	2011	IWC	6	Metal finishing
Ceramic Membranes: De-oiling and Produced Water Recovery, Operating Performance, Successes and Failures	Conference proceeding	R. Gay-de-Montella, Worley Parsons, T. Harding, V. Martez	2011	IWC	8	Oil and gas extraction
Piloting Conventional and Emerging Industrial Wastewater Treatment Technologies for the Treatment of Oil Sands Process Affected Water	Conference proceeding	Richard Mah, Rodney Guest, Pritesh Kotecha	2011	IWC	16	Oil and gas extraction
Concepts in Zero-Liquid Discharge	Conference proceeding	Christian, Melches; Matthias, Lowenberg; Gunter, Hofmann	2011	IWC	17	Steam electric power generating
Preliminary Assessment of a Thermal Zero Liquid Discharge Strategy for Coal-Fired Power Plants	Conference proceeding	H.A. Nebrig; Xinjun (Jason) Teng; David Downs	2011	IWC	13	Steam electric power generating
Solidification of FDG Wastewater with Fly Ash: Feasibility and Fate Analysis	Conference proceeding	Rudy Labban, Denise Horner, Mark Owens	2011	IWC	11	Steam electric power generating

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The Use of Constructed Wetlands in the Treatment of Flue Gas Desulfurization Wastewater	Conference proceeding	Jared Morrison, Christopher Snider, Dennis Haag	2011	IWC	14	Steam electric power generating
Produced Water Softener Regeneration Using Boiler Blowdown	Conference proceeding	Francis Boodoo, Stephen Moylan	2011	IWC	9	Oil and gas extraction
A Review of the Cooling Water Methods for Sodium Hypochlorite Activation of Sodium Bromide into a Hypobromous Acid – Hypobromite Biocide	Conference proceeding	Liz Harrelson, Jonathan Howarth, Courtney Mesrobian, Todd Shaver	2011	IWC	10	Non-classifiable establishments
Chemical Treatment and Fill Selection Methods to Minimize Scaling/Fouling in Cooling Towers	Conference proceeding	Brad Buecker, Ray Post, Rich Aull	2011	IWC	10	Non-classifiable establishments
Hydrodynamic Cavitation for Cooling Water Treatment: A Technology Update	Conference proceeding	Philip Vella	2011	IWC	10	Miscellaneous foods and beverages
Generating 'Light Work' Removing Heavy Metals	Industry publication	Rob Aldave, Steven Buday	2011	Pollution Engineering	4	Steam electric power generating
Regenerative Turbine Aeration Technology	Industry publication	Stuart Ward	2011	Pollution Engineering	4	Non-classifiable establishments
Pilot Field-scale Demonstration of a Novel Alum Sludge-based Constructed Wetland System for Enhanced Wastewater Treatment	Peer-reviewed journal	Y.Q. Zhao, A.O. Babatunde, Y.S. Hu, J.L.G. Kumar, X.H. Zhao	2011	Process Biochemistry	6	Agricultural services
Enhancement of Start-up of Pilot-scale Granular SBR Fed with Real Wastewater	Peer-reviewed journal	Yong-Qiang Liu, Yunhua Kong, Joo-Hwa Tay, Jianrong Zhu	2011	Separation and Purification Technology	7	Non-classifiable establishments
Petroleum Refinery Stripped Sour Water Treatment Using the Activated Sludge Process	Peer-reviewed journal	Rion Merlo, Matthew Gerhardt, Fran Burlingham, Carla De Las Casas, Everett Gill, T. Houston Flippin	2011	Water Environment Research	12	Petroleum refining
Removal of Organics and Nutrients from Food Wastewater Using Combined Thermophilic Two-phase Anaerobic Digestion and Shortcut Biological Nitrogen Removal	Peer-reviewed journal	Fenghao Cui, Seungho Lee, Moonil Kim	2011	Water Research	8	Non-classifiable establishments

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Bibliography of Articles Entered into IWTT*

**Table C-1. Bibliography of Articles Entered into IWTT to Date**

<b>Title</b>	<b>Document Type</b>	<b>Author(s)</b>	<b>Date</b>	<b>Journal or Publisher</b>	<b>Page Count</b>	<b>Industry</b>
Purification of High Copper and TDS Acid Mine Drainage Water Using F-LLXTM AMD VEPTM Liquid-Liquid Extraction Technology	Conference proceeding	Paul J. Usinowicz, Bruce F. Monzyk, Ann E. Lane, Tenisha Highsmith, Niharika Chauhan	2011	WEFTEC	9	Ore mining and dressing
Selenium Treatment of Mine Water Effluent in a Fluidized Bed Reactor (FBR)	Conference proceeding	Kar Munirathinam, Rangesh Srinivasan, Jeff J. Tudini, Tom A. Sandy, Tim D. Harrison	2011	WEFTEC	21	Coal mining
Use of Dissolved Gas Flotation for Clarification of Biological Solids from a Petroleum Refinery Activated Sludge System	Conference proceeding	Brian Foy, Dr. Enos Stover, Charles C. Ross, J. Patrick Pierce	2011	WEFTEC	14	Petroleum refining
Process Design for Simultaneously Removing Arsenic and Manganese	Conference proceeding	H. C. Liang, Samuel J. Billin, Joseph R. Tamburini	2011	WEFTEC	6	Coal mining
Conceptual Design and Evaluation of Zero Liquid Discharge Systems for Management of Industrial Wastewater	Conference proceeding	Kristen Jenkins, Tom Higgins, Jim Mavis, Tom Sandy, Laura Reid, Ken Martins	2011	WEFTEC	10	Steam electric power generating
Process Optimization of a Petroleum Refinery Wastewater Treatment Facility Using Process modeling and Site Specific Biokinetic Constants	Conference proceeding	Hank Andres, David Kujawski, Oliver Schraa, Che-Jen Lin, Arthur Wong	2011	WEFTEC	15	Petroleum refining
Soluble and Total Aluminum after NaOH Neutralization of Acid Rock Discharges	Conference proceeding	Ronald Neufeld, Xunchi Pu, Oscar Martinez Vazquez	2011	WEFTEC	8	Coal mining
Steel Slag Filtration for Extensive Treatment of Mining Wastewater	Conference proceeding	Dominique Claveau-Mallet, Scott Wallace, Yves Comeau	2011	WEFTEC	14	Coal mining
Use of Softening-Enhanced High Density Sludge Treatment to Recover Mine Water for Beneficial Irrigation Reuse	Conference proceeding	Jim Stefanoff, Darby Stacey, James Almaas, Greg Pulliam, Karen Meade	2011	WEFTEC	9	Ore mining and dressing
Framework for a Mixed-Culture Biofilm Model to Describe Oxidized Nitrogen, Sulfur, and Selenium Removal in a Biofilm Reactor	Conference proceeding	Joshua P. Boltz, Doris Brockmann, Thomas Sandy, Bruce R. Johnson, Glen T. Daigger, Kristen Jenkins, Kar Manirathinam	2011	WEFTEC	12	Non-classifiable establishments

*Appendix C:*  
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Activated Anaerobic Digestion with a Membrane Filtration System	Conference proceeding	S. Joh Kang, Kevin Olmstead, Oliver Schraa, Dai Hwan Rhu, Young Jin Em, Jang Kyu Kim, Joon H. Min,	2011	WEFTEC	19	CAFO
Chemical Treatment for Nitrite Nitrogen Removal from Stainless Steel Pickling Liquor Wastewater	Conference proceeding	Ryan A. Kirkland, A. Todd Lusk, Dr. Meint Olthof, David G. Gilles	2011	WEFTEC	7	Iron and steel manufacturing
Coal Seam Gas Water Treatment and Reuse Options	Conference proceeding	Graeme R. Lewis, Peter Baudish	2011	WEFTEC	16	Oil and gas extraction
Membranes for Wastewater Reclamation and Reuse for Petrochemical and Petroleum Refining Industries	Conference proceeding	Joseph Wong	2011	WEFTEC	12	Petroleum refining
Industrial Waste Waters Re-use: Application of 3FM High Speed Filtration and High Rate Softening as Pre-Treatment of Wastewaters from the High Water Consuming Pulp & Paper Sector	Conference proceeding	Marie-Pierre Denieul, Stephanie Mauchauffee, Eric Barbier, Gilles Le Calvez, Aurore De Laval, Marielle Coste	2011	WEFTEC	15	Pulp, paper and paperboard
Treatment of Acrylic Acid Production Wastewater Using a Submerged Anaerobic Membrane Bioreactor	Conference proceeding	Michael Allison, Kripa Singh, Jonathan Webb, Shannon Grant	2011	WEFTEC	11	Organic chemicals, plastics and synthetic fibers
Uranium (VI) Reduction Under Facultative Anaerobic Conditions	Conference proceeding	Simphiwe Chabalala, Evans M. N. Chirwa	2011	WEFTEC	9	Ore mining and dressing
Extreme Water Reuse: Recycling in a Food Products Industry	Conference proceeding	Nicholas B. Cooper, Tracy Barker, A.G. Fishbeck	2011	WEFTEC	8	Wholesale trade - durable goods
Pretreatment of Electronics Wastewater for Reuse: Removal of Calcium Using Controlled Hydrodynamic Cavitation	Conference proceeding	Sunjip Kim, Jin-Young Park, Yong-Woo Lee, Jae-Jin Lee, Yun-Kyu Choi, Kyu-Won Hwang, Philip Vella, Won-Kwon Lee	2011	WEFTEC	16	Electrical and electronic components

*Appendix C:*  
*Bibliography of Articles Entered into IWTT*

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Nitrification performance and microbial ecology of nitrifying bacteria in a full-scale membrane bioreactor treating TFT-LCD wastewater	Peer-reviewed journal	Liang-Ming Whang, Yi-Ju Wu, Ya-Chin Lee, Hong-Wei Chen, Toshikazu Fukushima, Ming-Yu Chang, Sheng-Shung Cheng, Shu-Fu Hsu, Cheng-Huey Chang, Wason Shen, Chung Kai Huang, Ryan Fu, Barkley Chang	2012	Bioresource Technology	8	Metal finishing
A Simultaneous Removal of Beryllium and Ammonium–nitrogen from Smelting Wastewater in Bench- and Pilot-scale Biological Aerated Filter	Peer-reviewed journal	Fang Sun, Wei-Ling Sun	2012	Chemical Engineering Journal	8	Nonferrous metals manufacturing
Hospital Wastewater Treatment by Membrane Bioreactor: Performance and Efficiency for Organic Micropollutant Elimination	Peer-reviewed journal	Lubomira Kovalova, Hansruedi Siegrist, Heinz Singer, Anita Wittmer, Christa S. McArdell	2012	Environmental Science & Technology	10	Hospital
Biosorption and Recovery of Chromium from Industrial Wastewaters by Using <i>Saccharomyces cerevisiae</i> in a Flow-Through System	Peer-reviewed journal	Giovanni Colica, Pier Cesare Mecarozzi, Roberto De Philippis	2012	Industrial & Engineering Chemistry Research	6	Metal finishing
Removal of Cr(VI) and Humic Acid by Heterogeneous Photocatalysis in a Laboratory Reactor and a Pilot Reactor	Peer-reviewed journal	Lucía d. C. Cid, María d. C. Grande, Eduardo O. Acosta, Berta Ginzberg	2012	Industrial & Engineering Chemistry Research	7	Non-classifiable establishments
Use of Constructed Wetland Systems with <i>Arundo</i> and <i>Sarcocornia</i> for Polishing High Salinity Tannery Wastewater	Peer-reviewed journal	Cristina S.C. Calheiros, Paula V.B. Quitério, Gabriela Silva, Luís F.C. Crispim, Hans Brix, Sandra C. Moura, Paula M.L. Castro	2012	Journal of Environmental Management	6	Leather tanning and finishing
Study of Permeate Flux in Micellar-enhanced Ultrafiltration on a Semi-Pilot Scale: Simultaneous Removal of Heavy Metals from Phosphorous Rich Real Wastewaters	Peer-reviewed journal	Piia Hayrynen, Junkal Landaburu-Aguirre, Eva Pongracz, Riitta L. Keiski	2012	Separation and Purification Technology	8	Fertilizer manufacturing
Selenium Treatment in Refinery Wastewater	Conference proceeding	Sudini Padmasiri, Ronald Olivacce, Charles Meyer	2012	WEFTEC	13	Petroleum refining

*Appendix C:*  
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Removal of Selenium in Refinery Effluent with Adsorption Media	Conference proceeding	Missy Hayes, Nancy Sherwood	2012	WEFTEC	12	Petroleum refining
Fate and Effect of Naphthenic Acids on Biological Wastewater Treatment Systems in Oil Refineries	Conference proceeding	Spyros G. Pavlostathis, Teresa Misiti, Ulas Tezel, Madan Tandukar	2012	WEFTEC	10	Petroleum refining
Breakpoint Chlorination of Petroleum Refinery WWTP Effluent	Conference proceeding	Carla L. De Las Casas, Matthew B. Gerhardt, Rion P. Merlo, T. Houston Flippin, Fran B. Burlingham, David S. Murray	2012	WEFTEC	14	Petroleum refining
Selenium Removal from Oil Refinery Wastewater Using Advanced Biological Metal Removal (ABMet®) Process	Conference proceeding	Yakup Nurdogan, Patrick Evans, Jill Sonstegard	2012	WEFTEC	13	Petroleum refining
Acid Mine Drain (AMD) Treatment to Achieve Very Low Residual Heavy Metal Concentrations	Conference proceeding	Miroslav Colic, Jack Hogan	2012	WEFTEC	23	Ore mining and dressing
Water Chemistry Considerations for Improving Molybdenum Removal at a Mine Water Treatment Facility	Conference proceeding	H. C. Liang, Glenn Wright, Joseph R. Tamburini, W. Brinson Willis	2012	WEFTEC	6	Ore mining and dressing
Remote High-Altitude Pilot Treatment System for Mining-Impacted Waters	Conference proceeding	Christina Progress, Ram Ramaswami, John DeAngelis, Tom Rutkowski	2012	WEFTEC	4	Ore mining and dressing
Pilot Testing of Selenium Removal in a Surface Coal Mine Water Containing High Nitrate and Selenium Concentrations	Conference proceeding	Matthew Gay, Rangesh Srinivasan, Kar Munirathinamm, Tom A. Sandy	2012	WEFTEC	18	Coal mining
Bench- and Pilot-Scale Testing of Ion Exchange and Zero Valent Iron Technologies for Selenium Removal from a Surface Coal Mine Run-Off Water	Conference proceeding	Ken Martins, Jeremy Johnson, Karen Leber, Rangesh Srinivasan, Bo Heller	2012	WEFTEC	21	Coal mining
Treatment of Fatty Wastewater from Food and Beverage Processing Industries	Conference proceeding	Markus Roediger, Ralph Teckenberg, Alexander Ghazinuri	2012	WEFTEC	9	Dairy products processing

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Treatment of Fatty Wastewater from Food and Beverage Processing Industries	Conference proceeding	Markus Roediger, Ralph Teckenberg, Alexander Ghazinuri	2012	WEFTEC	9	Meat and poultry products
Dissolved Air Flotation as Secondary Clarification	Conference proceeding	Houston Flippin, Larry Cuomo and Lynn Petersen	2012	WEFTEC	6	Dairy products processing
Industrial Water Treatment and Resource Recovery Using Anti-Fouling Membrane System for Brewery Wastewater	Conference proceeding	Joon H. Min, Young J. Eum, Charles Wardle, Allen Chen, Jarod Limke, Gi T. Park, Sang U. Kim, Jang K. Kim, Dae H. Rhu	2012	WEFTEC	8	Miscellaneous foods and beverages
Management of Soluble Organics in Produced and Flowback Waters with Swellable, Absorbent Glass	Conference proceeding	Paul Edmiston, Justin Keener, Shawn McKee, Scott Buckwald, Gregory Hallahan, Michael Grossman	2012	WEFTEC	14	Oil and gas extraction
MBR for Wastewater Recycling in Textile Industry the Experiences of an Operator from Idea to Implementation	Conference proceeding	R. Teckenberg, T. Pohlers, A. Ghazinuri, M. Hoffmeister, S. Schuler	2012	WEFTEC	8	Textile mills
Evaluation of PEG Biodegradability Using MBR and MBBR	Conference proceeding	Daniel B. Wilkinson, Katie L. Jones, Angela J. Walsh, Laura R. Crisman	2012	WEFTEC	11	Pharmaceutical manufacturing
MBBR to MBR – Unique Process Configuration for Pharmaceutical Wastewater Treatment/Reuse	Conference proceeding	Katie L. Jones, Daniel B. Wilkinson, Angela J. Walsh, Laura R. Crisman	2012	WEFTEC	12	Pharmaceutical manufacturing
Comparison of COD and Toxicity Removal during Activated Sludge and MBBR Treatment of Kraft Pulp Mill Effluent	Conference proceeding	Natália R. de Rezende, Ann H. Mounteer, Geovana C. Mozer, Eduarda O. Reis	2012	WEFTEC	11	Pulp, paper and paperboard
Fluidized Bed Bioreactor Technology: Implementation and Operation for Industrial Contaminated Water Treatment	Conference proceeding	Todd S. Webster, Dave Enegess, Sam Frisch	2012	WEFTEC	12	Centralized waste treatment
Fluidized Bed Bioreactor Technology: Implementation and Operation for Industrial Contaminated Water Treatment	Conference proceeding	Todd S. Webster, Dave Enegess, Sam Frisch	2012	WEFTEC	12	Coal mining

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Fluidized Bed Bioreactor Technology: Implementation and Operation for Industrial Contaminated Water Treatment	Conference proceeding	Todd S. Webster, Dave Enegeess, Sam Frisch	2012	WEFTEC	12	Inorganic chemicals manufacturing
Fluidized Bed Bioreactor Technology: Implementation and Operation for Industrial Contaminated Water Treatment	Conference proceeding	Todd S. Webster, Dave Enegeess, Sam Frisch	2012	WEFTEC	12	Petroleum refining
Pilot Study of Pulp & Paper Mill Effluent Treatment with MBR-RO System	Conference proceeding	Vetrivel Dhagumudi, Dr. Dongxu Yan	2012	WEFTEC	13	Pulp, paper and paperboard
Development of a Site Specific Toxicity-based Operating Guideline for Nitrite Nitrogen in a Petroleum Refinery Wastewater Discharge	Conference proceeding	David W. Johnston, Scott M. Anderson, David R. Marrs	2012	WEFTEC	11	Petroleum refining
Use of High-Pressure CO <sub>2</sub> for Concentrating CrVI from Electroplating Wastewater by Mg–Al Layered Double Hydroxide	Peer-reviewed journal	Xiangying Lv, Zhi Chen, Yongjing Wang, Feng Huang, Zhang Lin	2013	Applied Materials and Interfaces	5	Metal finishing
Optimization of Continuous Reactor at Pilot Scale for Olive-oil mill wastewater treatment by Fenton-like process	Peer-reviewed journal	Gassan Hodaifa, J.M. Ochando-Pulido, S. Rodriguez-Vives, A. Martinez-Ferez	2013	Chemical Engineering Journal	8	Miscellaneous foods and beverages
Treatment of Copper Wastewater Using Optimal Current Electrochemical–Coagulation	Peer-reviewed journal	Kyungtae Kim, Fenghao Cui, Hyunsik Yoon, Moonil Kim	2013	Environmental Technology	8	Electrical and electronic components
Complete Removal of Organic Contaminants from Hypersaline Wastewater by the Integrated Process of Powdered Activated Carbon Adsorption and Thermal Fenton Oxidation	Peer-reviewed journal	Weijun Zhang, Xiaoyin Yang, Dongsheng Wang	2013	Industrial & Engineering Chemistry Research	7	Organic chemicals, plastics and synthetic fibers
Nitrification Performance in a Membrane Bioreactor Treating Industrial Wastewater	Peer-reviewed journal	Lukas Dvorak, Jan Svojitka, Jiri Wanner, Thomas Wintgens	2013	Water Research	10	Non-classifiable establishments
Electrocoagulation: Performance in Treatment of Slop Water and Other Wastewaters	Conference proceeding	Alena Tetreault-Haarstad, Peter Dold, Tore Oian	2013	WEFTEC	17	Oil and gas extraction
Design and Performance of the First Full Scale Membrane Bioreactor Plant Treating Oil Refinery Effluent in Brazil	Conference proceeding	Ana Claudia Cerqueira, Tiago Lopes, Vania Santiago, Marcus Vallero, Joubert Trovati, Brian Arntsen, Wajahat Syed	2013	WEFTEC	12	Petroleum refining

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Treatment of Refinery Wastewater Containing High Concentrations of Chemical Oxygen Demand and Total Sulfides for Low Odor Processing through a Capacity-Challenged Bioreactor	Conference proceeding	Rich Clasen, Stan Heimburger, Mike Fagan, Mostafa Jahanian	2013	WEFTEC	13	Petroleum refining
Selenium Removal from a Refinery Wastewater: Integrated Approach from Source Control to Wastewater Treatment	Conference proceeding	Marinetti Mauro, Ciongoli Bernardino, Zaffaroni Carlo, Munirathinam Kar	2013	WEFTEC	18	Petroleum refining
EcoRight MBR Pilot Study Investigating Treatability of a Saudi Aramco Refinery Wastewater	Conference proceeding	William Cunningham, Chad Felch, Duane Smith, Thomas Vollstedt	2013	WEFTEC	21	Petroleum refining
Fracking Wastewater Treatment at Collection Facility	Conference proceeding	Miroslav Colic, Ray Guthrie, Ariel Lechter	2013	WEFTEC	13	Oil and gas extraction
Selenium Recovery for Beneficial Reuse from Zinc Smelting Processing at Low pH conditions	Conference proceeding	Jang K. Kim, Joon H. Min, Young Jin Eum, Eui J. Yang, Myeong J. Yu, Jungwoo Lee	2013	WEFTEC	11	Nonferrous metals manufacturing
MBR Based Treatment of Tractor Manufacturing Wastewater	Conference proceeding	Miroslav Colic, Ray Guthrie, Ariel Lechter	2013	WEFTEC	20	Metal finishing
Coke Oven Wastewater Treatment Using on Immersed Membrane Biological Reactor	Conference proceeding	Art Kuljian, Jr, Ben Mutton, Greg Shamitko	2013	WEFTEC	21	Petroleum refining
Optimization of the Alternate Cycling Process for Nutrient Removal in Industrial Wastewater Treatment Plants – Full Scale Study	Conference proceeding	Mónica de Gracia, Asun Larrea, and Malcolm Fabiyi	2013	WEFTEC	11	Transportation equipment cleaning
Activated Sludge Operation in the Extreme Conditions of MLSS, TDS, and Temperature	Conference proceeding	Jurek Patoczka, John Scheri	2013	WEFTEC	13	Iron and steel manufacturing
Activated Sludge Operation in the Extreme Conditions of MLSS, TDS, and Temperature	Conference proceeding	Jurek Patoczka, John Scheri	2013	WEFTEC	13	Landfills
Activated Sludge Operation in the Extreme Conditions of MLSS, TDS, and Temperature	Conference proceeding	Jurek Patoczka, John Scheri	2013	WEFTEC	13	Pharmaceutical manufacturing
Effect of Oxidic Conditions On the Performance of Membrane Bioreactor Systems – Pilot and Full Scale Evaluations	Conference proceeding	Karen Connery, Malcolm Fabiyi, Asun Larrea	2013	WEFTEC	11	Pharmaceutical manufacturing

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Effect of Oxidic Conditions On the Performance of Membrane Bioreactor Systems – Pilot and Full Scale Evaluations	Conference proceeding	Karen Connery, Malcolm Fabiyi, Asun Larrea	2013	WEFTEC	11	Textile mills
DAF Optimization: Production Increases Require Engineering and Automation to Achieve Operational Excellence and Continuous Improvement Goals	Conference proceeding	G. Swearingen, S. Dusenbery, C Scott-Woodfork, M Bradley, C. Bartz, J. Gideon	2013	WEFTEC	15	Petroleum refining
Development and Implementation of a Novel Sulfur Removal Process from H <sub>2</sub> S Containing Wastewaters	Conference proceeding	Glenn T. Diagger, Andrew Hodgkinson, Simon Aqualina, Kim Fries	2013	WEFTEC	13	Pulp, paper and paperboard
Full Scale Application of Ozone for Bulking Control at a Pulp & Paper Facility	Conference proceeding	Asun Larrea, Andoni Urruticoechea, Malcolm Fabiyi	2013	WEFTEC 2013	10	Pulp, paper and paperboard
Removal of Active Pharmaceutical Ingredients (APIs) from Wastewater - a review of existing treatment solutions	Conference proceeding	Achim Ried, Edward G. Helmig, Greg Claffey, Keel Robinson, Matthew J. DeMarco	2014	WEFTEC	16	Hospital
Removal of Active Pharmaceutical Ingredients (APIs) from Wastewater - a review of existing treatment solutions	Conference proceeding	Achim Ried, Edward G. Helmig, Greg Claffey, Keel Robinson, Matthew J. DeMarco	2014	WEFTEC	16	Pharmaceutical manufacturing
Start Up and Commissioning of a Membrane Bioreactor Plant Treating a High TDS Refinery Wastewater	Conference proceeding	Mauro Marinetti, Kar Munirathinam, Bernardino Ciongoli, Carlo Zaffaroni, Ali Redha	2014	WEFTEC	16	Petroleum refining
A Combined Biological and Advanced Oxidation Process for the Treatment of Wastewaters from the Microelectronics Industry.	Conference proceeding	Sunil Mehta, Nabin Chowdhury, Denise Horner, Antonio Lau, Barbara Schilling	2014	WEFTEC	11	Electrical and electronic components
Use of DSS-MBR-PACT Process to Improve Nitrification and AOX Removal in the Treatment of Herbicides Production Wastewater	Conference proceeding	Liron Shoshani, Chaim Sheindorf, Asher Brenner	2014	WEFTEC	17	Pesticide chemicals
One Automotive Manufacturer: Three Membrane Applications for Wastewater Pretreatment and Reuse	Conference proceeding	Lucy Pugh, Joan Gautier, Eric Van Orman, Cullum Pakosh, Duane Dehner	2014	WEFTEC	27	Aluminum forming

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One Automotive Manufacturer: Three Membrane Applications for Wastewater Pretreatment and Reuse	Conference proceeding	Lucy Pugh, Joan Gautier, Eric Van Orman, Cullum Pakosh, Duane Dehner	2014	WEFTEC	27	Metal finishing
Long Term Operation of Moving Bed Biofilm Reactor for Nitrification of a Refinery Effluent at Elevated Temperatures	Conference proceeding	R. Branco, E. Lannegrace, R. Lafond, C. Dale	2014	WEFTEC 2014	8	Petroleum refining
Phosphorous Removal from Industrial Wastewater Using Dissolved Air Flotation to Meet Discharge Requirements for the Chesapeake Bay Watershed	Conference proceeding	Charles C. Ross, J. Patrick Pierce, G. Edward Valentine	2014	WEFTEC 2014	14	Meat and poultry products
Flue Gas Desulfurization (FGD) Wastewater Best Available Technology Economically Achievable (BAT), 2015 Steam Electric Effluent Limitation Guidelines and Standards Rulemaking.	Government report	U.S. EPA Office of Water	2015		490	Steam electric power generating
Flue Gas Desulfurization (FGD) Wastewater Pretreatment Standards for New Sources (PSNS), 2015 Steam Electric Effluent Limitation Guidelines and Standards Rulemaking.	Government report	U.S. EPA Office of Water	2015		490	Steam electric power generating
Flue Gas Desulfurization (FGD) Wastewater Chemical Precipitation Treatment, 2015 Steam Electric Effluent Limitation Guidelines and Standards Rulemaking.	Government report	U.S. EPA Office of Water	2015		490	Steam electric power generating
Biological Treatment of Coke Plant Wastewater with Activated Sludge MBR Technology	Conference proceeding	Art Kuljian, Jeff Penny, Joshua Harrison	2015	WEFTEC	19	Iron and steel manufacturing
Mercury Removal from Coke Plant Waste Water: Process Design and Operational Optimization	Conference proceeding	Frank Jere, Joe Clute	2015	WEFTEC	6	Iron and steel manufacturing
Strong Enough? Piloting Aerobic vs. Anaerobic Treatment for Food and Beverage Wastewater	Conference proceeding	David Riedel, Octavio Casvantes, Jay Kulowiec	2015	WEFTEC	15	Canned and preserved fruits and vegetables processing
Model-based evaluation for the upgrade of an industrial wastewater treatment plant to enhanced biological phosphorus removal (EBPR)	Conference proceeding	Guclu Insel, Ozlem Ketenci, Gulsum Zengin, Emine Cokgor, Peter Dold	2015	WEFTEC	14	Textile mills

*Appendix C:*  
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Treatment of High-Strength Industrial Solvent Waste	Conference proceeding	Emil Schultz, Brad Carter, Ralph Schultz	2015	WEFTEC	9	Non-classifiable establishments
Characterization and treatability of mercury in a petroleum refinery wastewater discharge	Conference proceeding	K Sky Bellanca, David R Marrs	2015	WEFTEC	12	Petroleum refining

*Appendix D:*  
*Treatment Technology Performance Data in IWTT by Pollutant*

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**Treatment Technology Performance Data in IWTT by Pollutant**

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*Appendix D:*  
*Treatment Technology Performance Data in IWTT by Pollutant*

**Table D-1. Pollutants with Performance Data in IWTT**

<b>Pollutant<sup>a</sup></b>	<b>Number of Treatment Systems<sup>b</sup></b>
Acetic acid, 2-bromo-2-chloro	1
Acids, volatile fatty (as acetic acid)	1
Active Pharmaceutical Ingredients (APIs)	1
Adsorbable organic halides (AOX)	1
Alkalinity	1
Alkalinity (as CaCO <sub>3</sub> )	4
Alkalinity, bicarbonate (as CaCO <sub>3</sub> )	1
Alkalinity, total (as CaCO <sub>3</sub> )	2
Aluminum	3
Aluminum, total	5
Ammonia	5
Ammonia (as N)	17
Ammonia (as NH <sub>3</sub> )	10
Ammonia (as NH <sub>4</sub> )	4
Ammonia, total	6
Ammonia, total (as N)	3
Ammonia-nitrogen	6
Ammonium, nonvolatile	1
Ammonium, volatile	1
Ammonium-nitrogen	10
Ammonium-nitrogen (NH <sub>4</sub> -N)	3
Ampicillin	1
Antimony, total	3
Arsenic	7
Arsenic, total	3
Arsenic, total (as As)	1
Azithromycin	1
Barium	2
Barium, total	4
Benzene	2
Benzo(a)pyrene	2
Beryllium	1
Beryllium, total	3
Bisoprolol	1
BOD	27
BOD, carbonaceous, 05 day, 20 C	1
BOD, soluble	1
BOD, total	5
BOD5	12
Boron	3

*Appendix D:*  
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**Table D-1. Pollutants with Performance Data in IWTT**

<b>Pollutant<sup>a</sup></b>	<b>Number of Treatment Systems<sup>b</sup></b>
Boron, total	3
BTEX	4
Cadmium	11
Cadmium, total	3
Calcium	8
Calcium, total	3
Carbamazepine	1
Carbon dioxide (as CO <sub>2</sub> )	2
Carbon, dissolved organic (as C)	3
Carbon, tot organic (TOC)	18
Chemical oxygen demand	60
Chemical oxygen demand, dissolved	1
Chemical oxygen demand, soluble	6
Chemical oxygen demand, total	16
Chloride	12
Chloride, total	3
Chlorinated VOCs	1
Chlorine	1
Chlorine, total residual	1
Chloroform	1
Chlortetracycline (Aureomycin)	1
Chromium	10
Chromium, hexavalent	8
Chromium, total	7
Ciprofloxacin	2
Cobalt	1
Cobalt, total	3
Color (Pt-Co units)	2
Color, concentration at wavelength	4
Conductivity	12
Copper	11
Copper, total	7
Cyanide	4
Cyanide, total	4
Cyanide, total (as CN)	2
Cyanide, weak acid, dissociable	1
Dibromoacetic acid (DBAA)	1
Dichloromethane	1
Diclofenac	1
Dissolved oxygen (DO)	6

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*Treatment Technology Performance Data in IWTT by Pollutant*

**Table D-1. Pollutants with Performance Data in IWTT**

<b>Pollutant<sup>a</sup></b>	<b>Number of Treatment Systems<sup>b</sup></b>
Estrogenicity, 17-beta estradiol equivalent	1
Ethylbenzene	2
Ethylene glycol	1
Fats, oils and grease (FOG)	9
Fats, oils and grease, total (TFOG)	2
Fluoride	3
Haloacetic acids (HAA5)	1
Hardness (as CaCO <sub>3</sub> )	2
Hardness, Ca calculated (mg/L as CaCO <sub>3</sub> )	1
Hardness, Mg calculated (mg/L as CaCO <sub>3</sub> )	1
Hardness, total (as CaCO <sub>3</sub> )	1
Hydrogen sulfide	3
Iron	7
Iron, total	8
Lead	5
Lead, total	5
Magnesium	5
Magnesium, total	3
Manganese	4
Manganese, total	6
Mercury	6
Mercury, dissolved (as Hg)	1
Mercury, particulate	1
Mercury, total	4
Metronidazol	1
Molybdenum, total	3
Morphine	1
Naphthalene	2
Naphthenic acid	5
Nickel	13
Nickel, total	4
Nitrate	5
Nitrate (as N)	11
Nitrate (as NO <sub>3</sub> )	2
Nitrate/Nitrite as N	1
Nitrite (as N)	6
Nitrite (as NO <sub>2</sub> )	2
Nitrite plus nitrate (as N)	3
Nitrite Plus Nitrate Total	1
Nitrogen, inorganic total	1

*Appendix D:*  
*Treatment Technology Performance Data in IWTT by Pollutant*

**Table D-1. Pollutants with Performance Data in IWTT**

<b>Pollutant<sup>a</sup></b>	<b>Number of Treatment Systems<sup>b</sup></b>
Nitrogen, Kjeldahl total (TKN)	19
Nitrogen, Kjeldahl total (TKN) filtered	1
Nitrogen, organic	1
Nitrogen, total	14
Nitrogen, total (as N)	1
N-Methyl-2-pyrrolidone	1
n-Propylbenzene	1
Oil	2
Oil and grease	12
Oil and grease, hexane extr method	4
Oil and grease, SGT-HEM	1
Oil and grease, total	1
ORP	2
Oxygen demand, chem. (COD), dissolved	2
Oxygen demand, total	2
Perchlorate (ClO <sub>4</sub> )	1
Phenol	8
Phenol, nonvolatile	1
Phenol, volatile	1
Phenolic compounds, total	1
Phenols	5
Phosphate	3
Phosphate (as P)	3
Phosphate, ortho (as P)	1
Phosphate, total (as PO <sub>4</sub> )	1
Phosphorus	5
Phosphorus, total	23
Phosphorus, total (as P)	3
Phosphorus, total filtered	1
Selenate (VI)	2
Selenite (IV)	2
Selenium	6
Selenium, dissolved	3
Selenium, dissolved 0.45 um filter	1
Selenium, total	13
Silica, dissolved (as SiO <sub>2</sub> )	1
Silica, total (as SiO <sub>2</sub> )	2
Silicate (SiO <sub>4</sub> -2 as SiO <sub>2</sub> )	1
Silver	3
Silver, total	3

*Appendix D:*  
*Treatment Technology Performance Data in IWTT by Pollutant*

**Table D-1. Pollutants with Performance Data in IWTT**

<b>Pollutant<sup>a</sup></b>	<b>Number of Treatment Systems<sup>b</sup></b>
Sodium	5
Sodium, total	3
Sodium, total (as Na)	1
Solids, total	3
Solids, total dissolved (TDS)	26
Solids, total suspended (TSS)	7
Solids, total volatile	2
Solids, volatile suspended	7
Strontium, total (as Sr)	1
Sulfate	9
Sulfate (as S)	1
Sulfate (as SO <sub>4</sub> )	1
Sulfate, total	3
Sulfate, total (as SO <sub>4</sub> )	1
Sulfide	4
Surfactants	1
Suspended solids	4
Tetramethyl ammonium hydroxide	2
Thallium, total	3
Thiocyanate	3
Thiocyanate (filtered)	1
Tin	2
Tin, total	3
Titanium, total	3
Toluene	2
Total petroleum hydrocarbons	2
Total phenols	1
Total suspended solids	42
Trichloroacetic acid (TCAA)	1
Turbidity	9
Vanadium	1
Vanadium, total	3
Xylene	2
Zinc	10
Zinc, total	5

<sup>a</sup> Pollutant names are only as specific as the names stated in each article.

<sup>b</sup> A treatment system may target more than one pollutant. Additionally, the number of treatment systems is based on review of the articles collected as part of the literature review, presented in Appendix C.

Message

---

**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 6/27/2018 9:10:08 PM  
**To:** Whitlock, Steve [Whitlock.Steve@epa.gov]  
**Subject:** Presentation on Nutrients

Brian mentioned that you'd want to give a presentation on Nutrients at an ELG planning group meeting, but I haven't been able to check with you on when would work for you. Is that something you're interested in?

Phillip Flanders, Ph.D., P.E.

Environmental Engineer  
Engineering and Analysis Division  
Office of Science and Technology  
Office of Water



Mail Code 4303T  
(202) 566-8323  
[www.epa.gov/eg](http://www.epa.gov/eg)

## Message

**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 3/6/2019 3:13:35 PM  
**To:** Kim Wagoner [Kim.Wagoner@erg.com]; Molly McEvoy [Molly.McEvoy@erg.com]  
**Subject:** PP14 edits from Deborah  
**Attachments:** image2019-03-06-094613.pdf; Draft Prelim Plan 14 20190305\_tracked.docx

Good Morning!

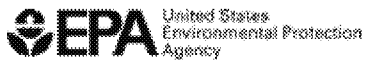
I have Deborah's edits to PP14. I would like to have a tracked changes version to give to Brian. Deborah made some comments about tables that I will need ERG's help with (no need to have tables in tracked changes – just leave a comment explaining what you did). And there are a couple of comments from me directed at ERG. Deliberative Process / Ex. 5

## Deliberative Process / Ex. 5

We can discuss on the 11:00 call.

Phillip Flanders, Ph.D., P.E.

Environmental Engineer  
Engineering and Analysis Division  
Office of Science and Technology  
Office of Water



Mail Code 4303T  
(202) 566-8323  
[www.epa.gov/eg](http://www.epa.gov/eg)

Message

---

**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 12/11/2018 5:57:00 PM  
**To:** Whitlock, Steve [Whitlock.Steve@epa.gov]; Kim Wagoner [Kim.Wagoner@erg.com]; Molly McEvoy [Molly.McEvoy@erg.com]; Liz Gentile [elizabeth.gentile@erg.com]  
**Subject:** FW: ELG Program Plan mark up  
**Attachments:** Draft Prelim Plan 14\_2018.11.21bdedits.docx

Brian made some edits to the most recent draft of Prelim Plan 14. Everything seems straightforward to me except some questions/comments in the nutrients section. I know it's short notice, but can we plan to discuss them on tomorrow's 11:00 call?

---

**From:** Damico, Brian  
**Sent:** Tuesday, December 11, 2018 12:27 PM  
**To:** Flanders, Phillip <Flanders.Phillip@epa.gov>  
**Subject:** ELG Program Plan mark up

Some edits, do you think we can turn this around by the end of the week? I'd like to try and get it to Rob.

Thanks!

-B

---

Brian D'Amico  
Chief, Technology and Analytical Support Branch  
Engineering and Analysis Division  
Office of Science and Technology  
U.S. Environmental Protection Agency  
Washington, DC  
(202) 566-1069 (Office)  
(202) 384-2190 (EPA Cell)

## Message

**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 1/17/2018 3:16:21 PM  
**To:** Whitlock, Steve [Whitlock.Steve@epa.gov]; Kim Wagoner [Kim.Wagoner@erg.com]; Born, Tom [Born.Tom@epa.gov]; Deborah Bartram [deborah.bartram@erg.com]; Elizabeth Gentile [elizabeth.gentile@erg.com]; Kimberly Bartell [Kimberly.Bartell@erg.com]; Cuff, Jalyse [cuff.jalyse@epa.gov]  
**Subject:** RE: 304m weekly calls

Okay!

---

**From:** Whitlock, Steve  
**Sent:** Wednesday, January 17, 2018 10:14 AM  
**To:** Kim Wagoner <Kim.Wagoner@erg.com>; Flanders, Phillip <Flanders.Phillip@epa.gov>; Born, Tom <Born.Tom@epa.gov>; Deborah Bartram <deborah.bartram@erg.com>; Elizabeth Gentile <elizabeth.gentile@erg.com>; Kimberly Bartell <Kimberly.Bartell@erg.com>; Cuff, Jalyse <cuff.jalyse@epa.gov>  
**Subject:** RE: 304m weekly calls

I'll be joining the call late today.  
 --Steve--

---

**From:** Kim Wagoner [mailto:Kim.Wagoner@erg.com]  
**Sent:** Wednesday, January 17, 2018 10:10 AM  
**To:** Flanders, Phillip <Flanders.Phillip@epa.gov>; Whitlock, Steve <Whitlock.Steve@epa.gov>; Born, Tom <Born.Tom@epa.gov>; Deborah Bartram <deborah.bartram@erg.com>; Elizabeth Gentile <elizabeth.gentile@erg.com>; Kimberly Bartell <Kimberly.Bartell@erg.com>; Cuff, Jalyse <cuff.jalyse@epa.gov>  
**Subject:** RE: 304m weekly calls

Good morning! Attached is the updated punch list. In addition for the agenda we have:

- Final 2016 Plan and Review Report

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- 
- 

## Deliberative Process / Ex. 5

- Preliminary 2018 Plan and Review Report

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## Deliberative Process / Ex. 5

- Pilot technology review

- IWTT

- 
- 

## Deliberative Process / Ex. 5

- EJ

- HELGA

- Kick-off meetings/calls – ERG delivered draft agendas on 11/20

- 

Deliberative Process / Ex. 5

- 
- 

Deliberative Process / Ex. 5

- Metal finishing report – Deliberative Process / Ex. 5

Anything else?

Kim Wagoner, P.E.  
Environmental Engineer  
ERG  
14555 Avion Parkway Suite 200  
Chantilly, VA 20151  
703-633-1620

-----Original Appointment-----

**From:** Kim Wagoner

**Sent:** Wednesday, May 17, 2017 12:44 PM

**To:** Kim Wagoner; Flanders, Phillip; [Whitlock.steve@Epa.gov](mailto:Whitlock.steve@Epa.gov); Born, Tom; Deborah Bartram; Elizabeth Gentile; Kimberly Bartell; [cuff.jalyse@epa.gov](mailto:cuff.jalyse@epa.gov)

**Subject:** 304m weekly calls

**When:** Wednesday, January 17, 2018 11:00 AM-12:00 PM (UTC-05:00) Eastern Time (US & Canada).

**Where:** Via conference call: [REDACTED]

All, we have to make a change to our call-in information for our weekly calls. Please note the new number below.

Call In [REDACTED]

Code: [REDACTED]

Appointment

---

**From:** Flanders, Phillip [/o=ExchangeLabs/ou=Exchange Administrative Group (FYDIBOHF23SPDLT)/cn=Recipients/cn=0cb247ef96f642f98cb727a9ed48e49e-Flanders, P]  
**Sent:** 8/22/2018 8:40:33 PM  
**To:** Lidgard, Michael [Lidgard.Michael@epa.gov]; Smith, DavidW [Smith.DavidW@epa.gov]; Zhang, Qian [Zhang.Qian@epa.gov]; Dunn, John [Dunn.John@epa.gov]; Baskin, Kilty [Baskin.Kilty@epa.gov]; Schweizer, Jonathan [schweizer.jonathan@epa.gov]; Jones, Erica [Jones.Erica@epa.gov]; Trulear, Brian [Trulear.Brian@epa.gov]; Obrien, Karen [obrien.karen@epa.gov]; Pimpare, Justin [Pimpare.Justin@epa.gov]; Chadwick, Dan [Chadwick.Dan@epa.gov]; Wen, Chen [Wen.Chen@epa.gov]; Roberts, Cindy [Roberts.Cindy@epa.gov]; Livnat, Alexander [Livnat.Alexander@epa.gov]; Swanson, Nicholas [Swanson.Nicholas@epa.gov]; Schillo, Bruce [Schillo.Bruce@epa.gov]; Kazior, Kathryn [Kazior.Kathryn@epa.gov]; Pickrel, Jan [Pickrel.Jan@epa.gov]  
**Subject:** Prelim ELG Plan 15 OS  
**Attachments:** PrelimPlan14 Briefing\_082118.docx  
**Location:** Conf Cal [REDACTED]  
**Start:** 9/5/2018 7:00:00 PM  
**End:** 9/5/2018 8:00:00 PM  
**Show Time As:** Tentative

Call In [REDACTED]  
Code [REDACTED]

ELG Planning Workgroup Members,

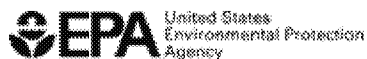
Thank you for your continued dedication to this project. We had our Options Selections meeting with the OW AA (Dave Ross) today (8/22). I would like to keep you all informed about what we are discussing, so I will give the same briefing to you that the AA received. I will also discuss some initial reactions and, if I receive decisions by the time of the call, I will communicate those as well. The briefing covered the suggested content of the next Preliminary ELG Program Plan. Please note that we are simplifying the names of the Plans by using numbers instead of years: this is Preliminary Plan 14. (The Final 2016 Plan was the 13<sup>th</sup> final plan that we have published. 13 plans in 28 years – not too bad!)

Also, please let me know if the workgroup representative for your office or region has changed.

Thank you,

Phillip Flanders, Ph.D., P.E.

Environmental Engineer  
Engineering and Analysis Division  
Office of Science and Technology  
Office of Water



Mail Code 4303T  
(202) 566-8323  
[www.epa.gov/eg](http://www.epa.gov/eg)



Message

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**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 8/21/2018 3:18:44 PM  
**To:** Higgs, Michele [higgs.michele@epa.gov]  
**Subject:** RE: Briefing Package - Preliminary ELG Program Plan 14: Options Selection  
**Attachments:** PrelimPlan14 Briefing\_082118.docx

Yes. Just a couple very minor last minute things – you know how it goes. Again, I'm sorry for the hassle.

---

**From:** Higgs, Michele  
**Sent:** Tuesday, August 21, 2018 11:14 AM  
**To:** Flanders, Phillip <Flanders.Phillip@epa.gov>  
**Subject:** RE: Briefing Package - Preliminary ELG Program Plan 14: Options Selection

Phillip, are you certain this is final? Many thanks.

M

---

**From:** Flanders, Phillip  
**Sent:** Tuesday, August 21, 2018 10:45 AM  
**To:** Crawford, Tiffany <Crawford.Tiffany@epa.gov>; Penman, Crystal <Penman.Crystal@epa.gov>  
**Cc:** Higgs, Michele <higgs.michele@epa.gov>  
**Subject:** RE: Briefing Package - Preliminary ELG Program Plan 14: Options Selection

I noticed a couple of typos. Would it be too much of a hassle to update? My apologies.

Phillip

---

**From:** Crawford, Tiffany  
**Sent:** Tuesday, August 21, 2018 10:11 AM  
**To:** Penman, Crystal <Penman.Crystal@epa.gov>  
**Cc:** Flanders, Phillip <Flanders.Phillip@epa.gov>; Higgs, Michele <higgs.michele@epa.gov>  
**Subject:** Briefing Package - Preliminary ELG Program Plan 14: Options Selection

Good Morning Crystal –

The briefing materials for tomorrow's briefing on the Preliminary ELG Program Plan 14: Options Selection, are attached. Please post at your convenience.

Thank you,

Tiffany N. Crawford  
Special Assistant  
US Environmental Protection Agency  
Office of Science and Technology  
Office of Water

**Other Contact Information:**

**Email:** [Crawford.Tiffany@epa.gov](mailto:Crawford.Tiffany@epa.gov)  
**Office:** (202) 566-2375

---

**From:** Flanders, Phillip  
**Sent:** Tuesday, August 21, 2018 9:54 AM  
**To:** Crawford, Tiffany <[Crawford.Tiffany@epa.gov](mailto:Crawford.Tiffany@epa.gov)>  
**Cc:** Wood, Robert <[Wood.Robert@epa.gov](mailto:Wood.Robert@epa.gov)>; Damico, Brian <[Damico.Brian@epa.gov](mailto:Damico.Brian@epa.gov)>  
**Subject:** Briefing Package

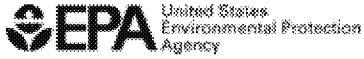
Tiffany,

I've attached the briefing package for our meeting tomorrow (8/22) with Dave Ross – Preliminary ELG Program Plan 14: Options Selection. Please forward it on so it can be posted as needed.

Thank you,

Phillip Flanders, Ph.D., P.E.

Environmental Engineer  
Engineering and Analysis Division  
Office of Science and Technology  
Office of Water



Mail Code 4303T  
(202) 566-8323  
[www.epa.gov/eg](http://www.epa.gov/eg)

Message

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**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 8/21/2018 2:45:01 PM  
**To:** Crawford, Tiffany [Crawford.Tiffany@epa.gov]; Penman, Crystal [Penman.Crystal@epa.gov]  
**CC:** Higgs, Michele [higgs.michele@epa.gov]  
**Subject:** RE: Briefing Package - Preliminary ELG Program Plan 14: Options Selection  
**Attachments:** PrelimPlan14 Briefing\_082118.docx

I noticed a couple of typos. Would it be too much of a hassle to update? My apologies.

Phillip

---

**From:** Crawford, Tiffany  
**Sent:** Tuesday, August 21, 2018 10:11 AM  
**To:** Penman, Crystal <Penman.Crystal@epa.gov>  
**Cc:** Flanders, Phillip <Flanders.Phillip@epa.gov>; Higgs, Michele <higgs.michele@epa.gov>  
**Subject:** Briefing Package - Preliminary ELG Program Plan 14: Options Selection

Good Morning Crystal –

The briefing materials for tomorrow's briefing on the Preliminary ELG Program Plan 14: Options Selection, are attached. Please post at your convenience.

Thank you,

Tiffany N. Crawford  
Special Assistant  
US Environmental Protection Agency  
Office of Science and Technology  
Office of Water

**Other Contact Information:**

**Email:** [Crawford.Tiffany@epa.gov](mailto:Crawford.Tiffany@epa.gov)  
**Office:** (202) 566-2375

---

**From:** Flanders, Phillip  
**Sent:** Tuesday, August 21, 2018 9:54 AM  
**To:** Crawford, Tiffany <[Crawford.Tiffany@epa.gov](mailto:Crawford.Tiffany@epa.gov)>  
**Cc:** Wood, Robert <[Wood.Robert@epa.gov](mailto:Wood.Robert@epa.gov)>; Damico, Brian <[Damico.Brian@epa.gov](mailto:Damico.Brian@epa.gov)>  
**Subject:** Briefing Package

Tiffany,

I've attached the briefing package for our meeting tomorrow (8/22) with Dave Ross – Preliminary ELG Program Plan 14: Options Selection. Please forward it on so it can be posted as needed.

Thank you,

Phillip Flanders, Ph.D., P.E.

Environmental Engineer  
Engineering and Analysis Division  
Office of Science and Technology  
Office of Water



Mail Code 4303T  
(202) 566-8323  
[www.epa.gov/eg](http://www.epa.gov/eg)

Message

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**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 3/13/2018 4:40:11 PM  
**To:** Born, Tom [Born.Tom@epa.gov]  
**Subject:** RE: 304m Work Plan  
**Attachments:** EP-C-17-041 Work Plan\_WA 0-05.pdf

Sure. I attached it.

---

**From:** Born, Tom  
**Sent:** Tuesday, March 13, 2018 12:12 PM  
**To:** Flanders, Phillip <Flanders.Phillip@epa.gov>  
**Subject:** 304m Work Plan

Phillip,

Will you please send me a copy of ERG's 304m work plan? I'd like to check the HELGA task language.

Thanks,

Tom

---

Ph: (202) 566-1001  
Fax: (202) 566-1053

U.S. Environmental Protection Agency  
Office of Water, Office of Science and Technology  
Engineering and Analysis Division  
Technology & Analytical Support Branch  
Mailcode 4303T  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460

FEDEX Address:  
US EPA Engineering and Analysis Division (6231)  
1301 Constitution Ave., NW  
Washington, DC 20004

Effluent Guidelines: [www.epa.gov/eg](http://www.epa.gov/eg)  
Analytical Methods: [www.epa.gov/cwa-methods](http://www.epa.gov/cwa-methods)

Message

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**From:** Sara Bossenbroek [Sara.Bossenbroek@erg.com]  
**Sent:** 9/14/2018 2:38:36 PM  
**To:** Whitlock, Steve [Whitlock.Steve@epa.gov]  
**CC:** Flanders, Phillip [Flanders.Phillip@epa.gov]; Kim Wagoner [Kim.Wagoner@erg.com]; Iti Patel [iti.patel@erg.com]; Molly McEvoy [Molly.McEvoy@erg.com]  
**Subject:** RE: Meeting to Discuss Nutrient Tool Data  
**Attachments:** Flow Outlier Magnitude Analysis\_091418.xlsx

Hi Steve,

We prepared the attached file to take an initial look at how many facilities have potential outlier flow values that could be inflating estimated loads. I pulled the estimated loads results for total nitrogen and total phosphorus from the Nutrient Tool into separate tabs, by facility, along with their reported flow and the estimated load for the corresponding Point Source Category ("TN\_Estimated Loads" and "TP\_Estimated Loads"). We'd like to talk through the spreadsheet and our suggested approach for identifying any potential outliers during our call at 11AM.

Thank you,  
Sara

---

**From:** Whitlock, Steve <Whitlock.Steve@epa.gov>  
**Sent:** Thursday, September 13, 2018 9:34 AM  
**To:** Molly McEvoy <Molly.McEvoy@erg.com>  
**Cc:** Flanders, Phillip <Flanders.Phillip@epa.gov>; Kim Wagoner <Kim.Wagoner@erg.com>; Sara Bossenbroek <Sara.Bossenbroek@erg.com>; Iti Patel <Iti.Patel@erg.com>  
**Subject:** RE: Meeting to Discuss Nutrient Tool Data

sure

---

**From:** Molly McEvoy [<mailto:Molly.McEvoy@erg.com>]  
**Sent:** Thursday, September 13, 2018 9:25 AM  
**To:** Whitlock, Steve <[Whitlock.Steve@epa.gov](mailto:Whitlock.Steve@epa.gov)>  
**Cc:** Flanders, Phillip <[Flanders.Phillip@epa.gov](mailto:Flanders.Phillip@epa.gov)>; Kim Wagoner <[Kim.Wagoner@erg.com](mailto:Kim.Wagoner@erg.com)>; Sara Bossenbroek <[Sara.Bossenbroek@erg.com](mailto:Sara.Bossenbroek@erg.com)>; Iti Patel <[iti.patel@erg.com](mailto:iti.patel@erg.com)>  
**Subject:** RE: Meeting to Discuss Nutrient Tool Data

Hi Steve,

How about tomorrow at 11am? We can send you an appointment with call-in details if that works for you.

Thanks,  
Molly

---

**From:** Whitlock, Steve <[Whitlock.Steve@epa.gov](mailto:Whitlock.Steve@epa.gov)>  
**Sent:** Thursday, September 13, 2018 8:52 AM  
**To:** Molly McEvoy <[Molly.McEvoy@erg.com](mailto:Molly.McEvoy@erg.com)>  
**Cc:** Flanders, Phillip <[Flanders.Phillip@epa.gov](mailto:Flanders.Phillip@epa.gov)>; Kim Wagoner <[Kim.Wagoner@erg.com](mailto:Kim.Wagoner@erg.com)>; Sara Bossenbroek <[Sara.Bossenbroek@erg.com](mailto:Sara.Bossenbroek@erg.com)>; Iti Patel <[iti.patel@erg.com](mailto:iti.patel@erg.com)>  
**Subject:** RE: Meeting to Discuss Nutrient Tool Data

Molly,

I'm available this afternoon 1-2 or 3-4 or anytime Friday 7:30-4:00, and next week M-F 8-11am. I agree that more QC is helpful when using these large databases that have many users inputting data.

--Steve--

---

**From:** Molly McEvoy [<mailto:Molly.McEvoy@erg.com>]

**Sent:** Wednesday, September 12, 2018 12:48 PM

**To:** Whitlock, Steve <[Whitlock.Steve@epa.gov](mailto:Whitlock.Steve@epa.gov)>

**Cc:** Flanders, Phillip <[Flanders.Phillip@epa.gov](mailto:Flanders.Phillip@epa.gov)>; Kim Wagoner <[Kim.Wagoner@erg.com](mailto:Kim.Wagoner@erg.com)>; Sara Bossenbroek <[Sara.Bossenbroek@erg.com](mailto:Sara.Bossenbroek@erg.com)>; Iti Patel <[iti.patel@erg.com](mailto:iti.patel@erg.com)>

**Subject:** Meeting to Discuss Nutrient Tool Data

Hi Steve,

We'd like to set up a call when you're free to discuss an approach to QC underlying data in the Nutrient Estimation Tool. We identified and corrected an outlier in the Meat and Poultry Category that was significantly inflating estimated nutrient loads. In this case, the error was not flagged in the Loading Tool or from our initial QC of reported DMR data. We think it would be a good idea to implement a more comprehensive QC to identify other potential cases where erroneous data from a single facility are inflating the results. Do you have time to discuss over the phone early next week?

Thanks,  
Molly

**Molly McEvoy**

Environmental Engineer

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Message

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**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 9/5/2018 8:49:50 PM  
**To:** Wood, Robert [Wood.Robert@epa.gov]  
**Subject:** FW: Rob's notes from the ELG Briefing  
**Attachments:** image2018-08-23-110110.pdf

I meant to send you the scan of your notes from the Options Selection briefing. Sorry for the delay.

---

**From:** Damico, Brian  
**Sent:** Thursday, August 23, 2018 12:56 PM  
**To:** Flanders, Phillip <Flanders.Phillip@epa.gov>  
**Subject:** Rob's notes from the ELG Briefing

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Brian D'Amico  
Chief, Technology and Analytical Support Branch  
Engineering and Analysis Division  
Office of Science and Technology  
U.S. Environmental Protection Agency  
Washington, DC  
(202) 566-1069 (Office)  
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**From:** DC-WJCW-6231-M@epa.gov [mailto:DC-WJCW-6231-M@epa.gov]  
**Sent:** Thursday, August 23, 2018 11:01 AM  
**To:** Damico, Brian <Damico.Brian@epa.gov>  
**Subject:**

Message

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**From:** Flanders, Phillip [/O=EXCHANGELABS/OU=EXCHANGE ADMINISTRATIVE GROUP (FYDIBOHF23SPDLT)/CN=RECIPIENTS/CN=0CB247EF96F642F98CB727A9ED48E49E-FLANDERS, P]  
**Sent:** 2/6/2018 4:10:48 PM  
**To:** Nurse, Leanne [Nurse.Leanne@epa.gov]  
**Subject:** FW: Concur Without Comment: OECA Response to the Final Agency Review for the Final 2016 Effluent Guidelines Program Plan (Tier 2, SAN 5601.2)  
**Attachments:** image2018-02-06-100645.pdf

Well here's OECA's!

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**From:** Redhead, Laurice  
**Sent:** Tuesday, February 06, 2018 11:07 AM  
**To:** Forsgren, Lee <Forsgren.Lee@epa.gov>  
**Cc:** Bodine, Susan <bodine.susan@epa.gov>; Hindin, David <Hindin.David@epa.gov>; Kelley, Rosemarie <Kelley.Rosemarie@epa.gov>; Flanders, Phillip <Flanders.Phillip@epa.gov>; Evalenko, Sandy <Evalenko.Sandy@epa.gov>; Nurse, Leanne <Nurse.Leanne@epa.gov>; Bartlett, Keith <Bartlett.Keith@epa.gov>; Segall, Martha <Segall.Martha@epa.gov>; VanTil, Barbara <vantil.barbara@epa.gov>  
**Subject:** Concur Without Comment: OECA Response to the Final Agency Review for the Final 2016 Effluent Guidelines Program Plan (Tier 2, SAN 5601.2)

Please see attachment!



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY  
WASHINGTON, D.C. 20460

OFFICE OF  
ENFORCEMENT AND  
COMPLIANCE ASSURANCE

**FEB 06 2018**

**MEMORANDUM**

**SUBJECT:** Concur Without Comment  
OECA Response to the Final Agency Review for the Final 2016 Effluent  
Guidelines Program Plan (Tier 2, SAN 5601.2)

**FROM:** Edward Messina, Director *Edward J. Messina*  
Monitoring, Assistance, and Media Programs Division  
Office of Compliance

**TO:** Lee Forsgren  
Deputy Assistant Administrator  
Office of Water

Thank you for the opportunity to review the Final Agency Review materials for the Final 2016 Effluent Guidelines Program Plan. OECA concurs without comment.

If you have any concerns, please contact Barbara Vantil, Chief of the Water Branch at (202) 564-0664.

cc: Susan Bodine, OECA  
David Hindin, OC  
Rosemarie Kelley, OCE  
Phillip Flanders, OW  
Sandy Evalenko, OW  
Leanne Nurse, OPEI  
Keith Bartlett, OECA  
Martha Segall, OC  
Barbara VanTil, OC





United States  
Environmental Protection  
Agency

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# **Preliminary 2016 Effluent Guidelines Program Plan**

June 2016

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U.S. Environmental Protection Agency  
Office of Water (4303T)  
1200 Pennsylvania Avenue, NW  
Washington, DC 20460

*EPA-821-R-16-001*

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**TABLE OF CONTENTS**

	<b>Page</b>
<b>1. EXECUTIVE SUMMARY .....</b>	<b>1-1</b>
<b>2. BACKGROUND.....</b>	<b>2-1</b>
2.1 The Clean Water Act and the Effluent Guidelines Program.....	2-1
2.2 Effluent Guidelines Review and Planning Process.....	2-3
2.2.1 Annual Review Process .....	2-4
2.2.2 Effluent Guidelines Program Plans.....	2-10
2.3 Effluent Limitations Guidelines and Pretreatment Standards Overview.....	2-11
2.3.1 Best Practicable Control Technology Currently Available (BPT) — CWA Sections 301(b)(1)(A) and 304(b)(1).....	2-12
2.3.2 Best Conventional Pollution Control Technology (BCT) — CWA Sections 301(b)(2)(E) and 304(b)(4) .....	2-13
2.3.3 Best Available Technology Economically Achievable (BAT) — CWA Sections 301(b)(2)(A) and 304(b)(2).....	2-13
2.3.4 New Source Performance Standards (NSPS) — CWA Section 306 .....	2-13
2.3.5 Pretreatment Standards for Existing Sources (PSES) — CWA Section 307(b).....	2-13
2.3.6 Pretreatment Standards for New Sources (PSNS) — CWA Section 307(c) .....	2-14
<b>3. 2015 EFFLUENT GUIDELINES PLANNING PROCESS AND METHODOLOGY .....</b>	<b>3-1</b>
3.1 Summary of the 2015 Annual Review Methodology .....	3-1
3.1.1 Toxicity Rankings Analysis (TRA).....	3-1
3.1.2 Preliminary Category Reviews .....	3-2
3.1.3 Review of Additional Industrial Categories and Pollutants.....	3-3
3.2 Discharges Excluded from EPA's 2015 Annual Review .....	3-3
3.2.1 Categories for Which EPA Has Recently Promulgated or Revised ELGs .....	3-4
3.2.2 Discharges Not Categorizable.....	3-4
3.3 Data Quality Assurance and Limitations .....	3-5
3.3.1 DMR and TRI Data.....	3-5
3.3.2 Other Data Sources Supporting EPA's 2015 Annual Review .....	3-8
<b>4. RESULTS OF THE 2015 ANNUAL REVIEW.....</b>	<b>4-1</b>
4.1 Findings from EPA's 2015 TRA and Preliminary Category Reviews .....	4-1
4.2 Findings from EPA's Review of Additional Industrial Categories and Pollutants.....	4-13
<b>5. INDUSTRIES FOR WHICH EPA IS CURRENTLY UNDERTAKING AN ELG     RULEMAKING .....</b>	<b>5-1</b>
5.1 EPA's Current Schedule for ELG Actions .....	5-1

---

**TABLE OF CONTENTS (Continued)**

	<b>Page</b>
<b>6. ONGOING EPA STUDIES OF INDUSTRIAL DISCHARGES .....</b>	<b>6-1</b>
6.1 Continued Detailed Study of the Petroleum Refining Category (40 CFR Part 419).....	6-1
6.2 Continued Detailed Study of CWT Category (40 CFR Part 437) .....	6-1
6.3 Continued Preliminary Study of the Metal Finishing Category (40 CFR Part 433).....	6-2
<b>7. OTHER ONGOING EPA REVIEWS .....</b>	<b>7-1</b>
<b>8. OTHER INITIATIVES .....</b>	<b>8-1</b>
<b>9. PRELIMINARY 2016 PLAN DECISIONS AND ACTIONS .....</b>	<b>9-1</b>
<b>10. SUMMARY TABLE OF FINDINGS FOR EXISTING GUIDELINE CATEGORIES FROM     THE 2015 ANNUAL REVIEW.....</b>	<b>10-1</b>
<b>11. SOLICITATIONS FOR PUBLIC COMMENT AND INPUT.....</b>	<b>11-1</b>
<b>12. REFERENCES FOR THE PRELIMINARY 2016 PLAN.....</b>	<b>12-1</b>

*List of Tables and Figures***LIST OF TABLES**

	<b>Page</b>
Table 3-1. Point Source Categories That Have Undergone Recent Rulemaking .....	3-4
Table 3-2. TRI and DMR Data Utility and Limitations.....	3-6
Table 4-1. Final 2015 Combined Point Source Category Rankings .....	4-2
Table 10-1. Summary of Findings from EPA’s 2015 Annual Review of Existing Industrial Categories.....	10-1

**LIST OF FIGURES**

	<b>Page</b>
Figure 2-1. Odd-Year Annual Review of Existing ELGs.....	2-7
Figure 2-2. Odd-Year Identification of Possible New ELGs.....	2-8
Figure 2-3. Even-Year Annual Review of Existing ELGs and Identification of Possible New ELGs .....	2-9
Figure 2-4. Further Review of Industrial Categories Identified During Annual Reviews.....	2-10
Figure 2-5. Regulations of Direct and Indirect Wastewater Discharges .....	2-12

## 1. EXECUTIVE SUMMARY

This *Preliminary 2016 Effluent Guidelines Program Plan* (Preliminary 2016 Plan), prepared pursuant to Clean Water Act (CWA) section 304(m), 33 U.S.C. § 1314(m), identifies any new or existing industrial categories selected for effluent guidelines rulemakings and provides a schedule for such rulemakings. It also discusses the results of EPA's annual review of effluent limitations guidelines and pretreatment standards (ELGs), consistent with CWA sections 301(d), 304(b), 304(g), and 304(m) (2015 Annual Review), and it includes EPA's evaluation of indirect discharge categories that do not have categorical pretreatment standards for the purpose of identifying potential new categories for which pretreatment standards under CWA section 307(b) might be warranted.

At this time, EPA has concluded that no additional industries warrant new or revised effluent guidelines. Therefore, EPA is not identifying any existing effluent guidelines for possible revision, nor is EPA identifying any new industries for an effluent guidelines rulemaking, aside from those currently undergoing a rulemaking.<sup>1</sup> EPA is also not identifying the development of any new or revised pretreatment standards at this time, beyond those that are currently under development.<sup>2</sup>

EPA plans to continue its review and/or study of several industrial categories and pollutant groups to determine if new or revised effluent guidelines are warranted, as announced in the *Final 2014 Plan Effluent Guidelines Program Plan* (Final 2014 Plan) (U.S. EPA, 2015a). These industrial categories consist of Petroleum Refining, Centralized Waste Treatment (CWT), Metal Finishing, Pesticide Chemicals, Engineered Nanomaterials Manufacturing and Formulating (ENMs), and Oil and Gas Extraction in Cook Inlet, Alaska. In addition, as announced in the Final 2014 Plan, EPA plans to continue to collect industrial wastewater treatment technology performance data for its Industrial Wastewater Treatment Technology (IWTT) Database, for use in future annual reviews. EPA also identified several additional categories for further review based on the findings from its 2015 Annual Review, as discussed below.

This Preliminary 2016 Plan and its conclusions are primarily supported by EPA's *2015 Annual Effluent Guidelines Review Report* (2015 Annual Review Report) (U.S. EPA, 2016a) which builds on prior annual reviews to identify certain pollutants in wastewater discharges in industrial categories which may not be adequately regulated by current ELGs. The 2015 Annual Review Report provides and explains the detailed data, analyses and other information EPA used in the 2015 Annual Review of industrial wastewater discharges, and is a part of the record for this Preliminary Plan. Annual Review Reports for prior years are part of the Annual Review record and can be found at [EPA's Effluent Guidelines Plan webpage](#).

EPA typically conducts a toxicity rankings analysis (TRA) of industrial categories in odd years and provides results in corresponding annual review reports. For the 2015 Annual Review EPA's TRA included those subject to existing ELGs and those not currently regulated by ELGs.

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<sup>1</sup> Effluent limitations guidelines and standards (ELGs) for the Canned and Preserved Seafood Category covering the Alaskan seafood processing subcategories are currently undergoing a rulemaking.

<sup>2</sup> Pretreatment standards for the Dental Category and the Oil and Gas Extraction Category, specifically relating to the discharge of pollutants from unconventional oil and gas extraction facilities, are currently under development.

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*I—Executive Summary*

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EPA then prioritized for further review those categories whose pollutant discharges may pose the greatest hazards to human health or the environment. From these 2015 TRA and preliminary category reviews, EPA identified three point source categories that warrant further review: Iron and Steel Manufacturing (40 CFR Part 420), Organic Chemicals, Plastics, and Synthetic Fibers (OCPSF) (40 CFR Part 414), and Pulp, Paper and Paperboard (40 CFR Part 430). EPA plans to continue its review of discharges from these categories during the 2016 annual review period, and report findings for these three categories in its *Final 2016 Effluent Guidelines Program Plan* (Final 2016 Plan).

In addition, as part of the 2015 Annual Review, EPA began reviewing in more detail three point source categories that were prioritized for further review based on public comments. These categories are Battery Manufacturing (40 CFR Part 461), Electrical and Electronic Components Manufacturing (40 CFR Part 469), specifically, Subpart B Electronic Crystals, and Rubber Manufacturing (40 CFR Part 428), Subpart A (Tire and Inner Tube Plants Subcategory).

EPA initiated these reviews to address comments received from stakeholders regarding new types of batteries that have been developed, and advances in electrical and electronics components manufacturing, since the current ELGs were developed. EPA initiated review of rubber manufacturing to determine whether 2-Mercaptobenothiazole (MBT), a chemical compound used in tire manufacturing, was being discharged.

EPA determined that additional review of Rubber Manufacturing related to the discharge of MBT from tire manufacturing is not warranted at this time because MBT's release into the environment is not due to industrial wastewater discharges but is primarily from the wear of tires on pavement, which is not under the purview of the ELG program. EPA plans to continue reviewing Battery Manufacturing and Electrical and Electronic Components manufacturing during the 2016 Annual Review.

During the 30-day public comment period for this Plan, EPA is soliciting public comment and data and information on several industrial wastewater discharge topics. See Section 11 of this Plan for a discussion of those topics for which EPA is soliciting comments. See the Federal Register Notice of Availability for this Plan for instructions on how, and where, to submit comments and information.

## 2. BACKGROUND

This section explains how the Effluent Guidelines Program fits into EPA's National Water Program, describes the general and legal background of the Effluent Guidelines Program, and summarizes EPA's process for making effluent guidelines revision and development decisions (i.e., effluent guidelines planning).

### 2.1 The Clean Water Act and the Effluent Guidelines Program

The CWA is based on the principle of cooperative federalism, with distinct roles for both EPA and the states, in which the goal is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. To that end, the Act is generally focused on two types of controls: (1) water quality-based controls, based on water quality standards, and (2) technology-based controls, based on ELGs.

The CWA gives states the primary responsibility for establishing, reviewing, and revising water quality standards. Water quality standards consist of designated uses for each water body (e.g., fishing, swimming, supporting aquatic life), criteria that protect the designated uses (numeric pollutant concentration limits and narrative criteria such as "no objectionable sediment deposits"), and an antidegradation policy. EPA develops recommended national criteria for many pollutants, pursuant to CWA section 304(a), 33 U.S.C. § 1314(a), which states may adopt or modify, as appropriate, to reflect local conditions. However, any modifications made by states to the criteria must be approved by EPA before they can take effect in a state's water quality standards under the Clean Water Act.

EPA is responsible for developing technology-based ELGs, based on best available technologies, for controlling industrial wastewater discharges. ELGs apply to pollutant discharges from industrial facilities directly to surface water (direct discharges) and to publicly owned treatment works (POTWs) (indirect discharges). For sources discharging directly to surface waters, permitting authorities—states authorized to administer the National Pollutant Discharge Elimination System (NPDES) permit program, and EPA in the few states that are not authorized—must incorporate EPA-promulgated limitations and standards into discharge permits, where applicable (U.S. EPA, 2010). For sources discharging indirectly to POTWs, EPA, a State, or an approved municipal "control authority" will typically issue a permit or control mechanism containing the appropriate effluent limitations and/or local limits in order to obligate a facility to be in compliance with the applicable standards and reporting requirements.

While technology-based ELGs in discharge permits are sometimes as stringent as, or more stringent than necessary to meet water quality standards, the effluent guidelines program is not specifically designed to ensure that regulated discharges meet the water quality standards of the receiving water body. For this reason, the CWA also requires authorized states to establish water quality-based effluent limitations where necessary to meet water quality standards. Water quality-based limits may require industrial facilities to meet requirements that are more stringent than those in a national effluent guideline regulation. In the overall context of the CWA, ELGs must be viewed as one tool in the broader set of tools and authorities Congress provided to EPA and the states to restore and maintain the quality of the nation's waters.

The 1972 amendments to the Federal Water Pollution Control Act (which then became known as the Clean Water Act) marked a distinct change in Congress's efforts "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (see CWA section 101(a), 33 U.S.C. 1251(a)). Before 1972, the law focused principally on water quality standards. This approach was challenging, however, because of the difficulty in determining whether a specific discharger or combination of dischargers was responsible for decreasing the water quality in a receiving stream.

The CWA directed EPA to promulgate ELGs that reflect pollutant reductions achievable by categories or subcategories of industrial point sources through the implementation of available treatment and prevention technologies. The ELGs are based on specific technologies (including process changes) that EPA identifies as meeting the statutorily prescribed level of control (see CWA sections 301(b)(2), 304(b), 306, 307(b), and 307(c)). Unlike other CWA tools, ELGs are national in scope and establish pollution control obligations for all facilities that discharge wastewater within an industrial category or subcategory. In establishing these controls under the direction of the statute, EPA assesses, for example: (1) the performance and availability of the pollution control technologies or pollution prevention practices for an industrial category or subcategory; (2) the economic achievability of those technologies, which can include consideration of the affordability of achieving the reduction in pollutant discharge; (3) the cost of achieving effluent reductions; (4) non-water quality environmental impacts (including energy requirements); and (5) such other factors as the EPA Administrator deems appropriate.

In passing the CWA, Congress viewed the creation of a single national pollution control requirement for each industrial category, based on the "best" technology the industry can afford, as a way to reduce the potential creation of "pollution havens" and to set the nation's sight on eliminating pollutant discharge to U.S. waters. Consequently, EPA's goal in establishing national ELGs is to ensure that industrial facilities with similar characteristics, regardless of their location or the nature of their receiving water, or POTW into which they discharge, will, at a minimum, meet similar effluent guidelines or pretreatment standards representing the performance of the "best" pollution control technologies or pollution prevention practices.

The Effluent Guidelines Program has helped reverse the water quality degradation that accompanied industrialization in this country. Permits developed using the technology-based industrial regulations are a critical element of the nation's clean water program and reduce the discharge of pollutants that have serious environmental impacts, including pollutants that:

- Kill or impair fish and other aquatic organisms.
- Cause human health problems through the consumption of contaminated water, fish, or shellfish.
- Degrade aquatic ecosystems.

EPA has promulgated effluent guidelines for 58 industrial categories (see Table 10-1, below); descriptions of all 58 industrial categories are available at [EPA's Industrial Effluent Guidelines webpage](#). These regulations apply to between 35,000 and 45,000 facilities that discharge directly to the nation's waters, as well as another 12,000 facilities that discharge to POTWs (i.e., indirect dischargers). Based on estimates of pollutant reductions from each separate

guideline, EPA has estimated that the regulations, cumulatively, have prevented the discharge of over 700 billion pounds of toxic pollutants annually.

## **2.2 Effluent Guidelines Review and Planning Process**

In addition to establishing new regulations, the CWA requires EPA to review existing effluent guidelines annually. EPA reviews all point source categories subject to existing effluent guidelines and pretreatment standards to identify potential candidates for revision, consistent with CWA sections 304(b), 301(d), 304(m)(1)(A) and 304(g). EPA also reviews industries consisting of direct-discharging facilities not currently subject to effluent guidelines to identify potential candidates for effluent guidelines rulemakings, pursuant to CWA section 304(m)(1)(B). Finally, EPA reviews industries consisting entirely or almost entirely of indirect-discharging facilities that are not currently subject to pretreatment standards, to identify potential candidates for pretreatment standards development under CWA section 307(b).

In the effluent guidelines planning process, EPA is guided by the following goals:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters.
- Provide transparent decision making and involve stakeholders early and often during the planning process.

EPA uses four major factors to prioritize existing effluent guidelines and pretreatment standards for possible revision. These factors were developed in EPA's draft National Strategy (U.S. EPA, 2002).

The first factor EPA considers is a combination of the amount and type of pollutants in an industrial category's discharge and the relative hazard posed by that discharge. This factor enables EPA to prioritize rulemakings that could produce the greatest environmental and health benefits.

The second factor EPA considers is the performance and cost of applicable and demonstrated wastewater treatment technologies, process changes, and pollution prevention alternatives that could effectively reduce pollutant concentrations in the industrial category's wastewater.

The third factor EPA considers is the affordability or economic achievability of the wastewater treatment technology, process change, or pollution prevention measures identified using the second factor. If the financial condition of the industry indicates that it would not be affordable to implement expensive and stringent new requirements, EPA might conclude that a less stringent or less expensive approach to reduce pollutant loadings would better satisfy applicable statutory requirements. EPA might also conclude that a wastewater treatment technology, process change, or pollution prevention measure was not economically achievable for a particular industry.

The fourth factor EPA considers is the opportunity to eliminate inefficiencies or impediments to pollution prevention or technological innovation, or opportunities to promote innovative approaches. This factor might also prompt EPA, during annual reviews, to decide

against revising an existing set of effluent guidelines or pretreatment standards if the pollutant source is already efficiently and effectively controlled by other regulatory or non-regulatory programs.

### **2.2.1 Annual Review Process**

EPA's annual review process includes an odd-and even-year annual review cycle, to address cohesively and comprehensively the factors laid out in EPA's draft National Strategy. In the odd-year reviews, EPA screens industrial dischargers through a toxicity rankings analysis (TRA) that identifies and ranks those categories whose reported pollutant discharges pose a substantial hazard to human health and the environment (See Figure 2-1 and Figure 2-2). EPA assesses the relative hazard of these discharges by applying toxic weighting factors (TWFs) to the annual pollutant discharges reported on discharge monitoring reports (DMRs); and to the Toxics Release Inventory (TRI) for a category to calculate the total discharge of toxic pollutants as toxic-weighted pound equivalents (TWPE) for a category. EPA then ranks the industrial categories based on total TWPE discharged.

In the even years, EPA reviews additional hazard data sources and conducts alternate analyses to enhance the identification of industrial categories for which new or revised ELGs may be appropriate (beyond those that traditionally rank high in the TRA). This is consistent with the Government Accountability Office (GAO) recommendation that EPA's annual review approach include additional industrial hazard data sources to augment its screening-level review of discharges from industrial categories.<sup>3</sup> Furthermore, EPA recognizes the value in considering, in the screening phase, the availability of treatment technologies, process changes, or pollution prevention practices that can reduce the identified hazards. Specifically, in the even-year reviews, EPA targets new data sources that will provide information not previously captured as part of the TRA, including, but not limited to, the following:

- Industrial process changes.
- Emerging contaminants of concern.
- Advances in treatment technologies and pollution prevention practices.
- Availability of new, more sensitive analytical methods.
- Other hazard data and information not captured in the TRA and/or suggested by stakeholders or by public comments.

Figure 2-3 illustrates the even-year review process. See Section 3 of this *Preliminary 2016 Effluent Guidelines Program Plan* (Preliminary 2016 Plan), for details on the methodology used specifically for EPA's 2015 Annual Review.

EPA also conducts a more detailed preliminary category review of those industrial discharge categories that (1) rank highest in terms of TWPE (i.e., pose the greatest hazard to human health and the environment) in the TRA, (2) are identified as warranting further review during the even-year analyses, or (3) are otherwise brought to its attention through stakeholder or

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<sup>3</sup> GAO's recommendations for the review of additional hazard data sources were published in GAO's September 2012 report *Water Pollution: EPA Has Improved Its Review of Effluent Guidelines But Could Benefit from More Information on Treatment Technologies*.

public comments. If EPA determines that further review is appropriate for an industrial category, EPA may complete a preliminary or detailed study of the point source category (see Section 2.2.1.1 and Section 2.2.1.2, respectively), which may eventually lead to a new or revised guideline.

#### **2.2.1.1 Preliminary Category Reviews**

EPA may conduct a preliminary category review for industrial categories (1) identified in the TRA as having the highest hazard potential, (2) identified as a priority by any of the even-year review analyses, or (3) otherwise brought to EPA's attention through stakeholder or public comments. EPA is particularly likely to conduct a preliminary category review if it lacks sufficient data to determine whether regulatory action would be appropriate (as illustrated in Figure 2-4). EPA may complete preliminary category reviews as part of the annual review cycle, depending on the industrial categories warranting review at that time or may extend the review into the next cycle. In its preliminary category reviews, EPA may examine the following: (1) wastewater characteristics and pollutant sources, (2) the pollutants driving the toxic-weighted pollutant discharges, (3) availability of pollution prevention and treatment, (4) the geographic distribution of facilities in the industry, (5) any pollutant discharge trends within the industry, and (6) any relevant economic factors. First, EPA attempts to verify the toxicity ranking results or pollutant discharges identified as a priority from other sources and fill in data gaps. Next, EPA considers the factors that may be contributing to these discharges. These include, for example, whether the discharges are primarily driven by a few facilities or are more widespread within a category. These assessments provide an additional level of quality assurance for the reported pollutant discharges and number of facilities that represent the majority of toxic-weighted pollutant discharge. EPA may also review readily available technologies and approaches for reducing the discharges.

During a preliminary category review, EPA may consult data sources including, but not limited to the following: (1) the U.S. Economic Census, (2) TRI and DMR data, (3) trade associations and reporting facilities that can verify reported releases and facility categorizations, (4) regulatory authorities (states and EPA regions) that can clarify how category facilities are permitted, (5) NPDES permits and their supporting fact sheets, (6) EPA effluent guidelines technical development documents, (7) relevant EPA preliminary data summaries or study reports, and (8) technical literature on pollutant sources and control technologies. If a preliminary category review reveals that the reports of toxic discharges are correct and are likely to be the result of the production practices widely used throughout the category, or technology approaches may exist for further controlling the pollutants, EPA may decide to conduct a preliminary or detailed study prior to initiating a rulemaking.

#### **2.2.1.2 Preliminary and Detailed Studies**

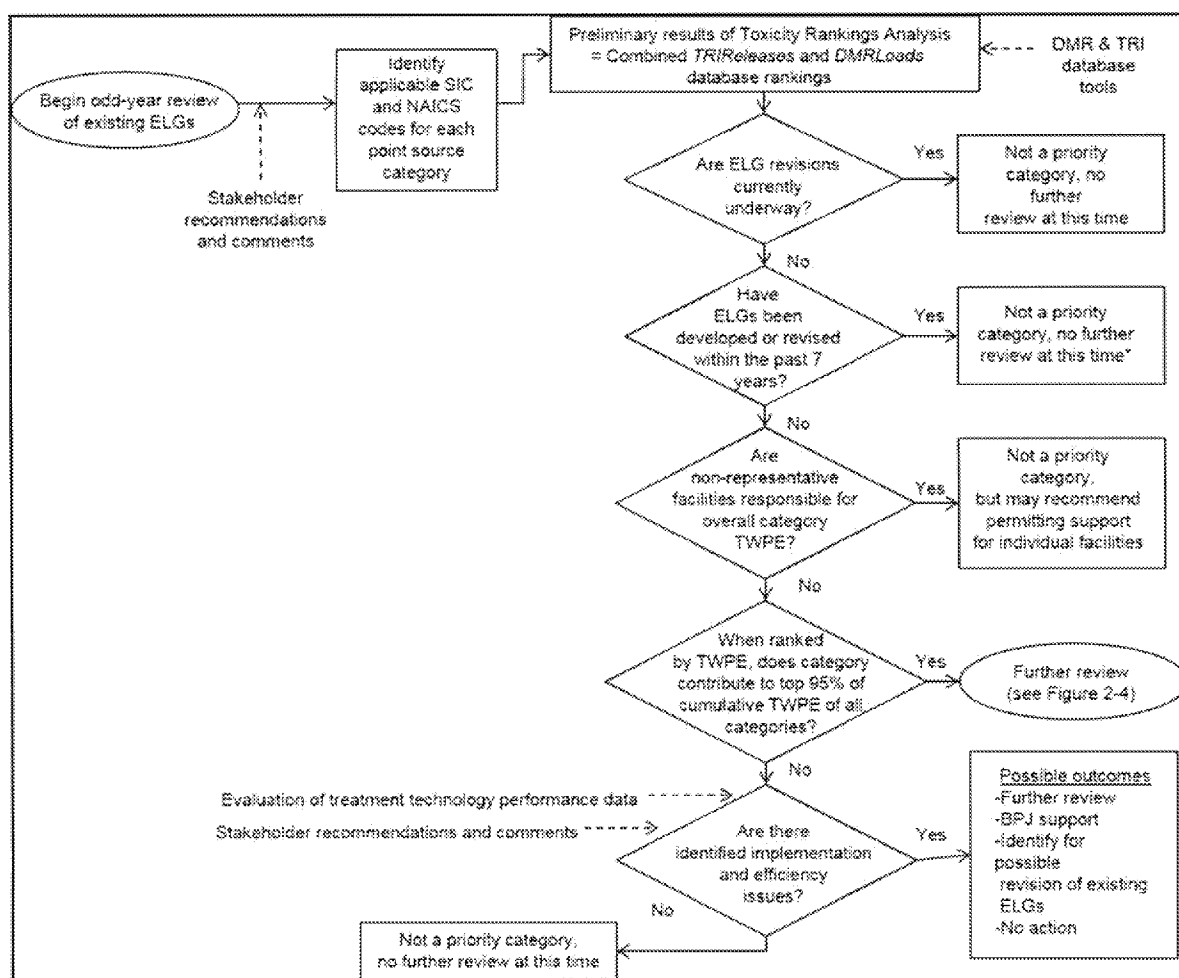
After conducting the preliminary category reviews (depicted in Figure 2-4), EPA may then conduct a study, at different levels of detail, of an industrial category. Typically, EPA has conducted two types of studies: preliminary studies and detailed studies. A preliminary study is usually more introductory in its level of information collection and evaluation than a detailed study. Both types of studies usually profile an industry category, gather information about its wastewater discharges, collect information about availability and cost of treatment and pollution

prevention technologies, assess the financial status of the facilities in the category, and investigate other factors to determine if it would be appropriate to identify the category for possible effluent guidelines revision. During preliminary or detailed studies, EPA also typically examines the factors and data sources listed above for preliminary category reviews. However, during a detailed study, EPA's examination of a point source category and available pollution prevention and treatment options is generally more rigorous than the analyses conducted during a preliminary category review or preliminary study, and may include primary data collection activities, such as industry questionnaires and wastewater sampling and analysis, to fill data gaps. In many cases, the information and data gathered for a study comprises the basis of the rulemaking. However, in other instances, the additional data and information gathered may indicate that a new or revised guideline is not warranted. Regardless of the outcome, EPA describes for the public and other stakeholders its decisions to conduct studies, or to develop rulemakings, in the Effluent Guidelines Program Plan.<sup>4</sup> When a rulemaking is determined appropriate, schedules are also described in the Plan.

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<sup>4</sup> While EPA describes such decisions in its plans, EPA may elect to describe them first on its website or through a venue other than the plan.

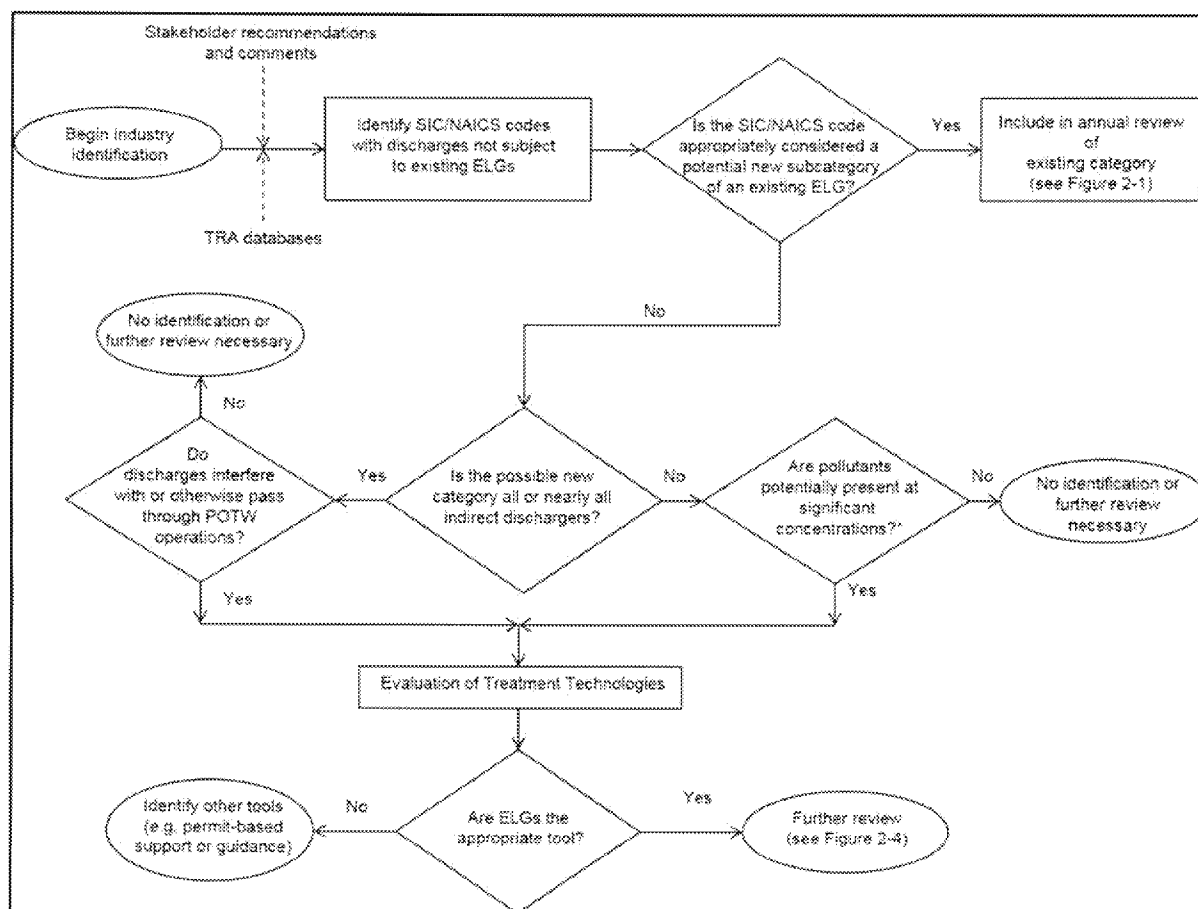
## 2—Background



\* If EPA is aware of new segment growth within such a category or new concerns are identified, EPA may do further review.

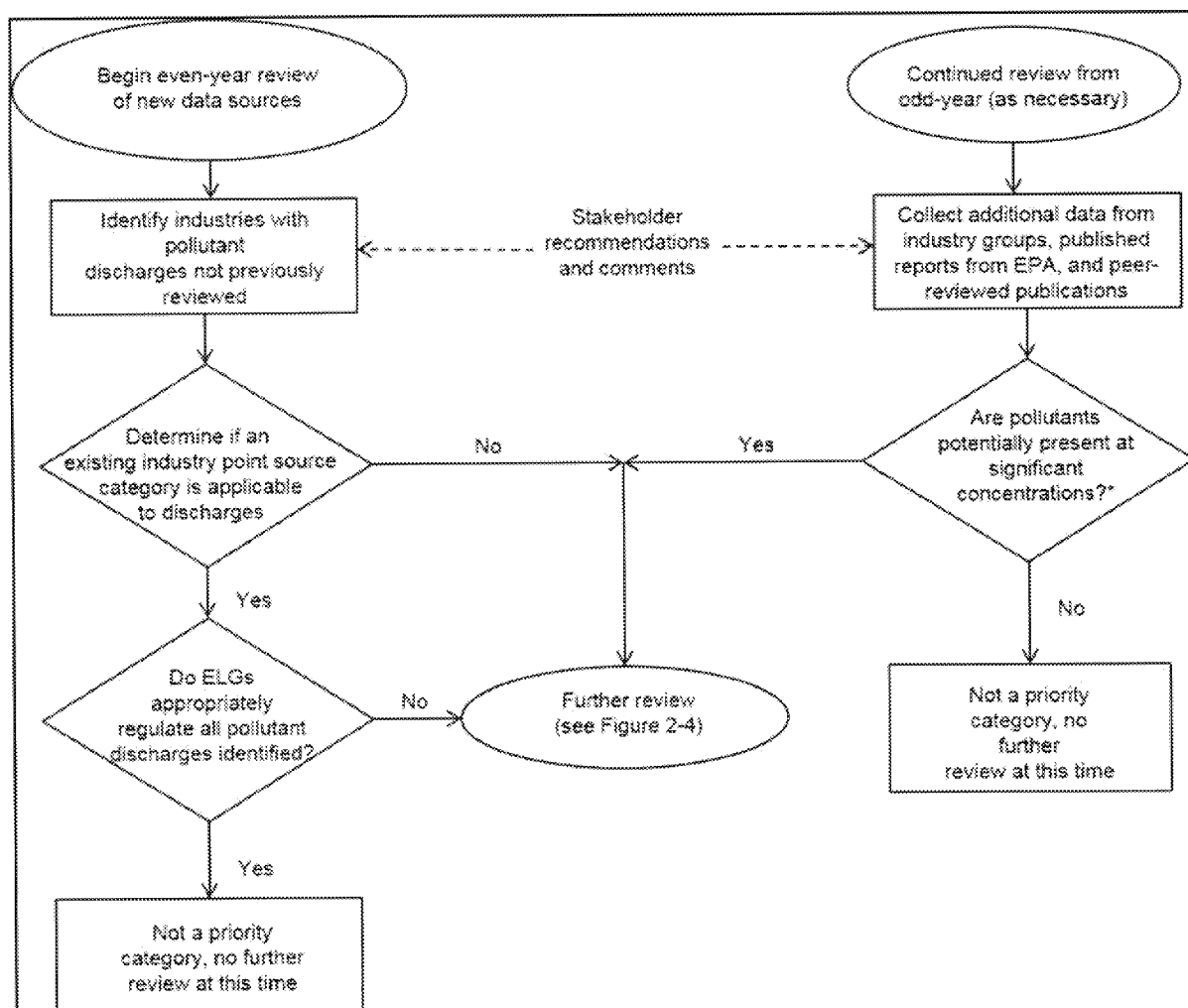
Figure 2-1. Odd-Year Annual Review of Existing ELGs

## 2—Background



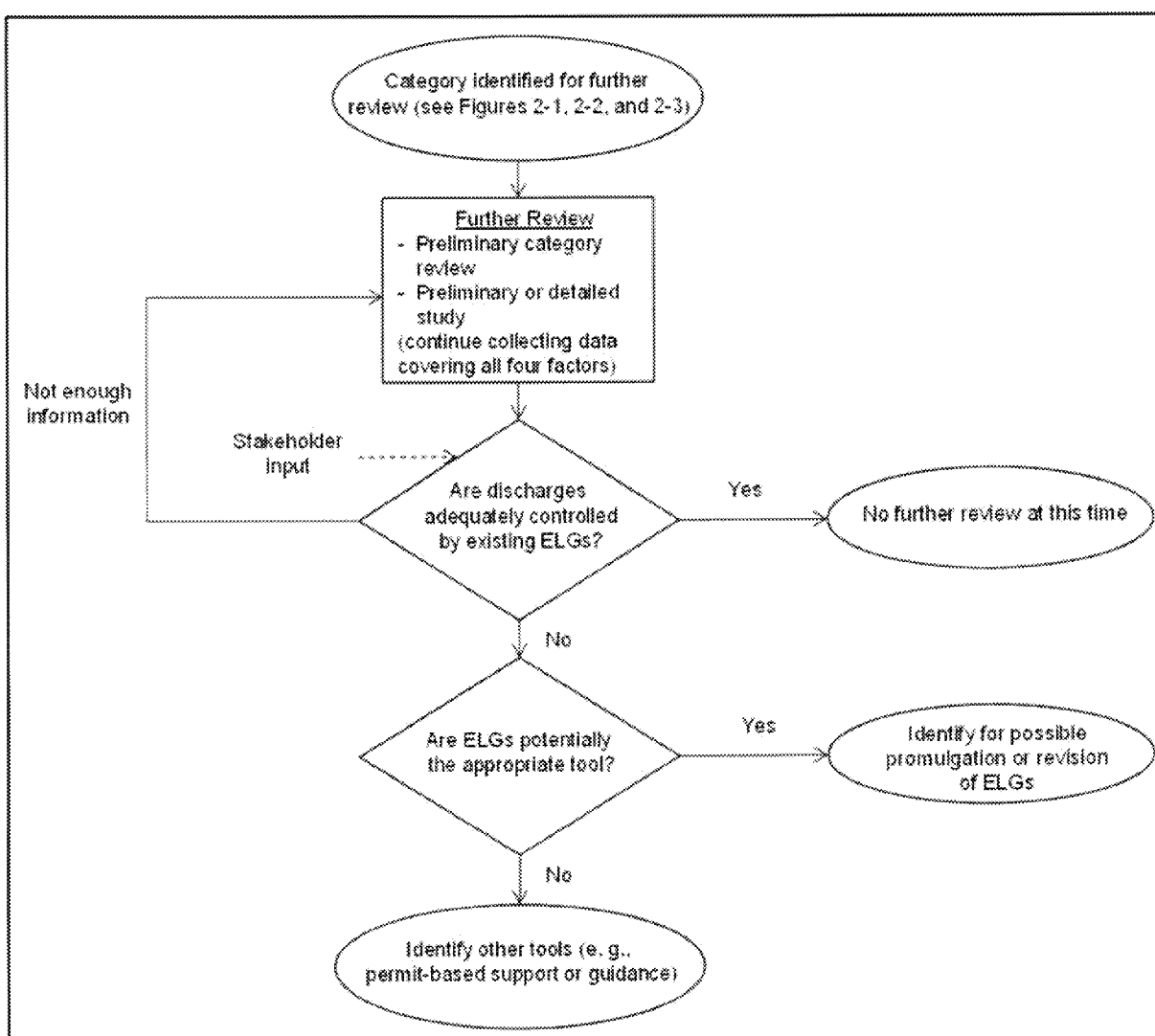
\* Significant concentrations may include levels above minimum levels from 40 CFR Part 136 or other EPA-approved methods, levels above treatable levels, or levels of concern to human health and toxicity.

**Figure 2-2. Odd-Year Identification of Possible New ELGs**



\* Significant concentrations may include levels above minimum levels from 40 CFR Part 136 or other EPA-approved methods, levels above treatable levels, or levels of concern to human health and toxicity.

**Figure 2-3. Even-Year Annual Review of Existing ELGs and Identification of Possible New ELGs**



**Figure 2-4. Further Review of Industrial Categories Identified During Annual Reviews**

### 2.2.2 Effluent Guidelines Program Plans

CWA section 304(m)(1)(A) requires EPA to publish an Effluent Guidelines Program Plan (Plan) every two years that establishes a schedule for the annual review and revision, in accordance with section 304(b), of the ELGs that EPA has promulgated under that section. EPA's *2015 Annual Effluent Guidelines Review Report* (2015 Annual Review Report) presents the results of its ELG reviews (U.S. EPA, 2016a). The 2015 Annual Review Report provides and explains the detailed data, analyses and other information EPA used in the 2015 annual review of industrial wastewater discharges, and is a part of the record for this Preliminary Plan.

Under the even- and odd-year annual review approach described above in Section 2.2.1, EPA coordinates its annual reviews of existing ELGs under section 304(b) with its publication of Preliminary and Final Plans, under CWA section 304(m). As a result, Final Plans typically

present the compilation of the odd- and even-year reviews and any public comments received on the Preliminary Plan. EPA may initiate, continue, or complete preliminary category reviews or in-depth studies during the odd- or even-year reviews. Additionally, EPA may publish the conclusions from these studies as part of the Preliminary or Final Plan, based on when during the planning cycle the study or review is completed.

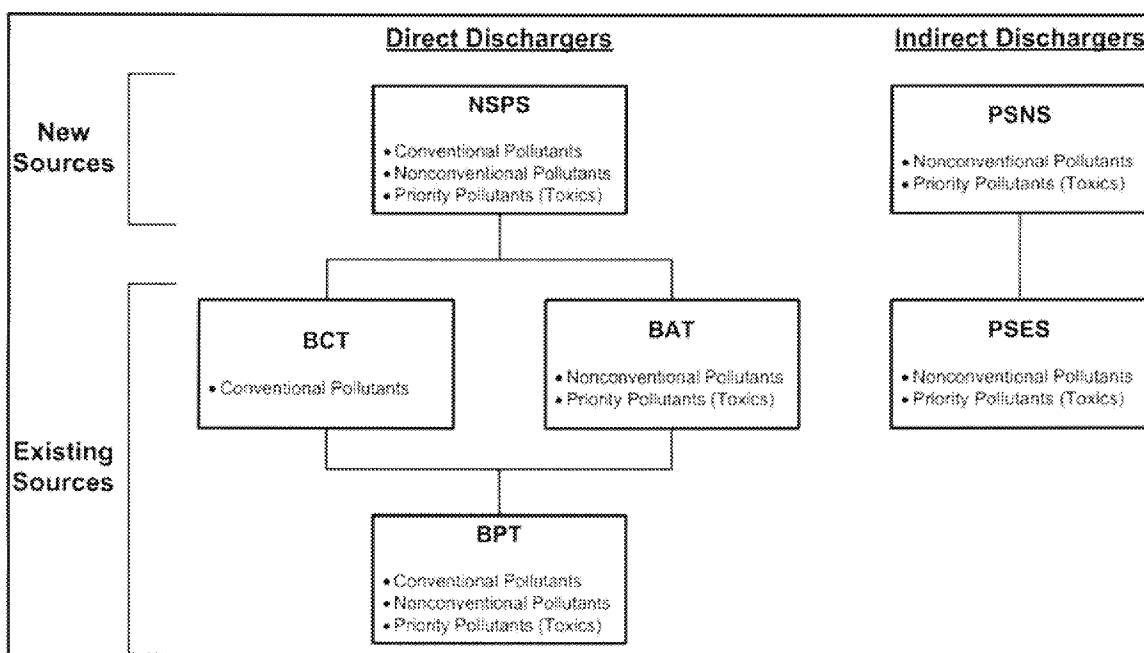
EPA coordinates its annual reviews under section 304(b) with publication of Plans under section 304(m) for several reasons. First, the annual reviews are inextricably linked to the planning effort because each review year's results can inform the content of the Preliminary and Final Plans (e.g., by identifying candidates for ELG revision, or by identifying point source categories for which EPA has never promulgated ELGs). Second, even though it is not required to do so under either section 304(b) or section 304(m), EPA serves the public interest by periodically describing the annual review results (including the review process). Doing so while simultaneously publishing the Preliminary and Final Plans makes both processes more transparent. Third, by requiring EPA to review existing ELGs each year, EPA understands Congress to have intended for each successive review to build on the results of earlier reviews.

### **2.3 Effluent Limitations Guidelines and Pretreatment Standards Overview**

The effluent guidelines program is one component of the Nation's clean water program, established by the 1972 Clean Water Act and subsequent amendments. The effluent guidelines program is authorized under CWA sections 301, 304, 306, and 307, 33 U.S.C. §§ 1311, 1314, 1316, 1317. In summary, the CWA directs EPA to promulgate categorical regulations through the following six levels of control:

1. Best practicable control technology currently available (BPT).
2. Best conventional control technology (BCT).
3. Best available technology economically achievable (BAT).
4. New source performance standards (NSPS).
5. Pretreatment standards for existing sources (PSES).
6. Pretreatment standards for new sources (PSNS).

For point sources that discharge pollutants directly into surface waters (direct dischargers), the effluent limitations and standards promulgated by EPA are implemented through NPDES permits (see CWA sections 301(a), 301(b), 402; 33 U.S.C. §§ 1311(a), 1311(b), 1342). For point sources that discharge to POTWs (indirect dischargers), EPA promulgates pretreatment standards that apply directly to those sources and are enforced by POTWs and by state and federal authorities. See CWA sections 307(b), 307(c); 33 U.S.C. § 1317(b), 1317(c). Figure 2-5 illustrates the relationship between the regulation of direct and indirect dischargers.



**Figure 2-5. Regulations of Direct and Indirect Wastewater Discharges**

### **2.3.1 Best Practicable Control Technology Currently Available (BPT) — CWA Sections 301(b)(1)(A) and 304(b)(1)**

EPA develops effluent limitations based on BPT for conventional, toxic, and nonconventional pollutants. CWA section 304(a)(4) designates the following as conventional pollutants: biochemical oxygen demand (BOD<sub>5</sub>), total suspended solids, fecal coliform, pH, and any additional pollutants defined by the Administrator as conventional. The Administrator designated oil and grease as an additional conventional pollutant on July 30, 1979 (see 44 FR 44501). EPA has identified 65 pollutants and classes of pollutants as toxic, among which 126 specific substances have been designated priority toxic pollutants (see Appendix A to Part 423, reprinted after 40 CFR Part 423.17). All other pollutants are considered to be nonconventional.

In specifying BPT, EPA looks at numerous factors. EPA first considers the total cost of applying the control technology in relation to the effluent reduction benefits. It also considers the age of the equipment and facilities, the processes employed and any required process changes, engineering aspects of the control technologies, non-water-quality environmental impacts (including energy requirements), and such other factors the EPA Administrator deems appropriate (see CWA section 304(b)(1)(B)). Traditionally, EPA establishes BPT effluent limitations by averaging the best performances of facilities of various ages, sizes, processes, or other common characteristics within the industry. Where existing performance is uniformly inadequate, BPT may reflect higher levels of control than currently in place in an industrial category, if EPA determines that the technology can be applied practically.